eSchool Garden

Design and Management of School Gardens

GRUPO COOPERATIVO CAJAMAR

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DESIGN AND LAYOUT
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ISBN-13: 978-84-95531-60-5
Release Date: July 2021

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Introduction

1. INTRODUCTION

A school garden is a natural, living laboratory comprising a small, usually fenced, plot of land in which the soil is prepared for the sowing of herbs, aromatic plants, spices, vegetables, pulses and fruit trees, among others.

The knowledge of plant development processes helps students to better appreciate the value of nature and the food they eat, since they understand where it comes from and how it grows.

Therefore, the education provided within the school garden is considered an important aspect in achieving the goal of food security.

That is to say; the objective of ensuring that everybody has access to a wholesome diet and knows how to eat healthily.

A school garden enables pupils to directly experience the sowing, planting and cultivation of plants in natural fields, thus combining theory and practice.

Experimentation gives students the opportunity to acquire greater skills to achieve a better quality of life through healthy eating, not only for themselves, but for their family and community too.

Source: Gettyimages

A school garden is a small-scale model of a farm where decisions such as: What we are going to plant or sow, how we are we going to work, when, who does what, how to behave when faced with the problems that come our way and what to do with the harvest, are taken on a daily basis.

Garden management requires:

- Evaluating there sources according to our needs, analysis and determination is therefore necessary.
- Carrying out frequent, shared social and scientific action.
- Sharpening the senses to look and see, to smell and perceive, to touch and appreciate, to hear and listen, to taste, savour and delight ourselves.

The main objective is to facilitate the knowledge of the elements of the environment and their importance for life. Among the other objectives are the following:

- To encourage direct contact with the land, its needs and possibilities.
- To learn to appreciate what nature gives us if we take care of it and respect it, creating affective ties with the natural environment.
- To value the importance of consuming fresh fruit and vegetables grown by oneself.
- To learn to consume water responsibly, not to waste it.
- To make use of natural resources and to put it into practice by recycling organic waste.
- To study, from a scientific point of view, the development process of living beings: from birth to death (in this case, of plants).
- To enjoy a natural environment although living in a city.
- Encourage cooperative attitudes, through teamwork, to main tain the school garden well.

Source: Gettyimages

2

Garden Location

2.

Garden Location

Determining size and location of garden on the school grounds, orientation, alternative water supply

A garden can be established on available land on the school grounds. If there is not enough land with topsoil, pots, baskets, boxes, and other containers filled with soil, or any other substrate, can be used. School gardens are used to grow plants with edible seeds, roots, leaves, flowers and fruit.

The educational centre can be inspected to determine available areas and spaces where certain crops can be grown, these will become part of the school garden. Those areas and spaces do not necessarily have to be large plots of land; but rather places where plants can develop in the best possible conditions.

To establish a plot as a garden, there are certain requirements, the following must be looked out for during the tour of the educational centre:

- Available water for crop irrigation (the water source could be mains, well, river or even from a rainwater collection system). Assess whether there are nearby water outlets to which hoses, or a drip irrigation system can be attached. If possible, measure the pressure with a manometer, checking that it is adequate for an automated drip irrigation system (higher than 1 kg/m^2). Watering cans, buckets and even a hose connected to a bathroom tap, etc, can also be used.

- Easy access for students, people with reduced mobility and for transporting supplies and materials.
- Prevent the access of animals and of people from outside the educational center.
- Permit light to enter by avoiding the shade of trees or nearby walls.
- Gentle slope. If the land is on a slope, soil conservation work is recommended. Conservation work that can be carried out to avoid soil erosion if necessary: terraces, contours, planting of live barriers and placement of inert barriers, etc.
- Free from any source of contamination such as: rubbish dumps, chemical product spills.

Source: Gettyimages

- Free of any potential hazards such as electrified areas. If the plot is outside the school grounds, avoid having to cross access roads to reach it.
- The soil should be free of stones to a shallow depth. If feasible, find an area of the school where there is soil, without stones or rubble, that is as deep and spongy as possible.
- It is always better to locate the garden in a place which is exposed to the sun for most of the day. To do this, it is best for it to be south facing (that is, any building, wall or mound that can cast a shadow must be to the north of the garden). When planning the direction of the furrows, it is better to have them running north-south, so that the light is well distributed.

Source: Gettyimages

3

Infraestructure

3.

Infraestructure

Type of soil cultivation, outdoors or under cover (greenhouse), materials and tools…

The medium in which plants are grown is soil, although hydroponic crops, which are grown in water with dissolved nutrients or soilless growing systems, which are grown in an artificial substrate with a nutrient solution, are also a possibility. Soil is the space where plants develop, but it should not merely be considered a means of propping up the plant. Soil contains many of the nutrients the plant requires to grow and live.

For soil fertility to be maintained, crop association, rotation, fallowing (leaving it without a crop), inputs such as manure and other organic amendments (compost) and fertilizers are recommended at times. The purpose of all these practices is for the soil to recover the nutrients removed by the plants.

Depending on the specific characteristics that predominate in certain soils, they are better or worse suited for certain crops and this will, therefore, determine the way it is to be treated or worked. Soils are classified by their texture or particle size as: sandy or light, loam (usually considered the best for vegetable plots and gardens) and clayey.

From a chemical point of view, sandy soils tend to contain fewer nutrients. Regarding physical properties, they are poorly structured, well aerated, highly permeable, with a low water retention capacity. On the other hand, clay soils are very active chemically speaking, they tend to be richer in nutrients, they retain a lot of water, are well structured, but if they are not properly managed, they can lead to excess moisture in the roots of the plants.

Loamy soils are usually the most suitable for growing most crops since both their texture and properties are balanced.

In general, soils require organic inputs (manure, worm humus, compost ...) to improve their structure and fertility, which enables more adequate management, allowing better water retention and aeration of the roots.

In the case of clay soils, which are either waterlogged or very compacted, in addition to organic amendments, river sand may be added, which will facilitate drainage and aeration. The addition of vegetable mulch or compost will also make the ground spongier.

One important aspect, which is not always considered, is that soil is a living entity, in which there is other life in addition to that of the plants which are grown in it. There are endless microorganisms and other living beings that make up their own ecosystem, and therefore caution must be exercised when treating the land (pesticides, fertilizers, etc.) since the existence of many these living beings is beneficial to the plants' development.

Different Types of School Gardens

A. Gardens in the Ground

These are school gardens directly in the ground, using the soil already present there. In this type of garden, teachers and students must ensure that the type of soil is suitable for plants to grow. Indicators to look out for; spontaneous vegetation (weeds), absence of flooding after rain indicating that they are well-drained and deep.

Source: Gettyimages

B. Raised beds

This type of garden comes in handy, above all, when working with young children as these raised beds prevent them from stepping on what has been planted. In addition, they are more convenient since it is not necessary to bend over to work. To build them, it is first necessary to mark out a long and narrow space, (the plants in the middle must be able to be reached without too much effort). Once defined, the land must be tilled to ensure that the soil is aerated, then a kind of border must be erected around the perimeter, the material used for this can vary. Once this is done, it must be filled with soil to be able to grow in it.

Source: Gettyimages

C. Growing Tables

Growing tables are gardens built inside tables, at a certain height if you want the plants to be located above ground level. This is the best option in the absence of land to grow directly in the soil. Growing tables are usually used for urban gardens, on terraces or in any space that is available outdoors with access to sunlight. A growing table consists of a table which can be filled to a certain depth with soil for plant cultivation. These can be either bought or home-made. Furthermore, the table does not necessarily need a cavity, it can be used as a base for plant pots, taking into account that the more soil there is, the more that can be grown. However, there are certain plants like potatoes or carrots which need deeper soil for their roots to develop properly. The good thing about this type of surface is that it is very convenient to handle and work with. The pupils' height must be considered when purchasing or making the tables since the higher they are, the more difficult it will be for the pupils to work on them. The downside is that it greatly limits the number of plants that can be grown. It is recommended to use mixtures of light substrates, which at the same time provide water retention capacity, drainage, nutrients and produce spongy soil.

Source: Gettyimages

Regarding the soil: Either a mix of two thirds universal substrate with a third of mulch-based nutrients or, two thirds peat or coconut fibre mixed with a third worm humus. It is necessary to ensure the tables have holes in the lowest points to ensure proper drainage and so avoid the possible accumulation of water, which can cause plant root asphyxia.

D. Potted gardens

They are the gardens in plant pots and are generally used in highly built-up areas that do not have the necessary natural conditions. For these gardens, as with the growing tables, the soil used must be purchased commercially from a specialized site or filled with soil from an agricultural plot or allotment. To improve drainage, as in the case of the growing tables, the base of the table or pot can be filled with gravel or pebbles, in order to ensure good drainage.

Source: Gettyimages

E. Greenhouses

Greenhouses are surfaces protected by a closed structure of transparent or translucent glass or plastic that lets in sunlight. They are especially useful in places with cold climates or to accelerate production times since the structure itself enables the greenhouse effect (hence its name) to take place during the sunlight hours and consequently there is an increase in temperature inside the enclosure. The effect will be greater or lesser depending on how well insulated it is, the volume of the greenhouse and the number of plants inside. It is important to keep a temperature record, since there is no guarantee that in very cold areas there will be no frost and, on the other hand, very high temperatures can be reached when solar radiation levels go up. To avoid this, the greenhouse must be ventilated, preferably using the roof vents. Proper ventilation is also important to avoid an excessively humid climate as this can lead to the development of fungi on plants.

Source: Gettyimages

F. Screenhouses

A screenhouse has a similar structure to that of a greenhouse, but its purpose is to provide shade and prevent the entry of insects. Therefore, instead of glass or transparent plastic they are covered with an anti-insect mesh or netting which can be made of transparent, black or coloured plastic threads, among other materials. They have differing degrees of shading and allow air to pass through while preventing the entry of possible insect pests. Indoor plants, which need less sunlight, can also be grown there.

Source: Gettyimages

Tools and Materials

Certain tools are required be able to work in the garden, without which the tasks would be overly complicated. However, it is convenient to bear in mind the small stature and limited strength of the people using them in the garden. That is why it is always advisable to acquire the right size tools which do not weigh too much.

Source: Gettyimages

Mattock: Used both for digging and for moving earth, making furrows, weeding, making holes for planting, levelling soil or breaking clods.

Short-bladed mattock: It is used for uprooting, weeding, levelling and turning the soil. As it is lighter it is more recommended smaller users.

Spade: Used for the same tasks as a mattock, but it is more suitable for wetter, clayey areas.

Trowel: Used to make small holes for transplanting or sowing.

Rake: Used collect dry leaves and grass, to loosen or smooth topsoil, or to break its capillarity (root threads) and to mix the seeds with the soil when sowing.

Fork: Used for spreading manure and tilling the soil, when making a mulch it is also handy for moving straw.

Hand Tiller: This tool is used for tilling or small-scale ploughing of the garden. It is ideal for loosening the soil between the rows and weeding during germination and the early development stages of spontaneous vegetation (weeds).

Wheeled Hand Tiller: If the garden is large, a wheeled tiller with which you can cover more ground with less effort can be used. This tool works like the previous one, but as it is wheeled, it is more convenient for carrying out the tasks (as it is larger it is also necessary be more careful with the plants, for smaller jobs the previous one is recommended). Another advantage of this tool is that its different attachments enable it to be used to till, make furrows and weed. It is commonly known as a bicycle.

Pruning Shears (Secateurs): As the name suggests, these are used for pruning plants, it is advisable to always use shears so that the cuts are clean, and the plant is caused no more damage than necessary. After each use they should be cleaned and disinfected since a dirty cut can lead to an infected plant. They are used for harvesting, to cut plant branches, and can even be used to cut bamboo canes to be used for tutoring.

Watering Can: Appropriate for use in watering small areas, for irrigation during transplanting and for plants or trees that do not have a specific irrigation system. A hose connected to an easily accessible tap to fill them for watering by hand.

Taking proper care of tools saves money and makes gardening easier. The tools should be put away in a suitable place, out of the sun and rain, following each use. It is advisable to clean and grease the metal parts after use, being especially be careful with the pruning shears since a dirty edge can cause the spread of diseases to the plant during pruning.

Source: Gettyimages

Source: Gettyimages

4

Crop Choice & Seedling Nursery

4.

Crop Choice & Seedling Nursery

Crop, variety, planting time, management techniques, crop rotation design…

An interesting aspect is connecting the pupils with the idea and concept of seasonal products, local production and knowledge of the crops grown in their area. In this sense, it would be more appropriate, with the crops that are feasible, to resort to local varieties, identified in the area, with a Protected Geographical Indication (PGI), Denomination of Origin (DO), and are representative products of the region, province, or municipality. Plant crop varieties that are recognizable and with which the pupils can identify. Choose species whose life cycle coincides with the months of the school year, so that they can recognize the different phases of cultivation, including harvest and carry out all the cultural practices, from sowing, planting, crop monitoring, to the more delicate maintenance tasks (pruning, pollination, grafting, etc.), irrigation, fertilization and harvesting.

A criterion to be used when choosing crops should be to consider how gratifying it can be to eat vegetables freshly picked from the garden. The possibilities that they can provide us with to carry out activities and experiments must also be considered. Also, when choosing the species and varieties to grow, it is interesting to tend towards those which allow us to plant the same species by staggering them and planting over a few

weeks. Thus, for example, if we grow spinach, chard, or lettuces we will be able to sow a few seeds every week, during most of the year.

The most difficult factors to control, and which limit the development of any crop are; temperature, daylight hours and relative humidity.

The temperature and number of daylight hours to which a plant is subjected will determine the beginning and the duration of the vegetative phases: germination, development, flowering, fruiting, and maturation. Apart from the number of hours of exposure, it is also convenient to know the light intensity since direct and intense exposure is much more effective than indirect and less intense, so determining the quantity and quality of what is grown. Garden plants generally require a minimum of six hours' exposure to sunlight a day, or at least, the luminosity (even indirect light) they are exposed to should be as prolonged and as intense as possible. It is therefore necessary to select, and take advantage of, the sunniest and warmest places for the plants that require the most light and temperature.

The ideal growing temperature for most plants is between 20 and 25 ºC, below 10 ºC many plants' growth stops and some of their functions may be limited. At temperatures in excess of 35 ºC, some of the functions of most plants, such as growth and fertilization are also limited and alterations that reduce the quality of fruits or organs can occur. Temperatures below 0 ºC, can cause frost destroying certain organs such as flowers, tender shoots, and fruits. If the temperature drops below a certain level, the plant itself can be destroyed. In some cases, it may recover but, depending on the type of frost, some species will be unable to regrow.

Crop Choice and Propagation Methods

Upon setting up a school garden one of the most important aspects is to choose the crops properly. The length of the school year is one of the main criteria to be taken into account. Pupils should be able to see and get to know all stages of the crop's development: sowing, growth, organ formation and harvesting.

Another criterion regarding crop choice, is to consider local varieties, those which are part of local culture or gastronomy or because of their economic importance. It is also important for the pupils to get to know the different ways the fruit, leaves, inflorescences, roots, bulbs, etc. of horticultural products are used.

Here is a presentation of several possible crops whose life cycles coincide with the school year.

Cabbages

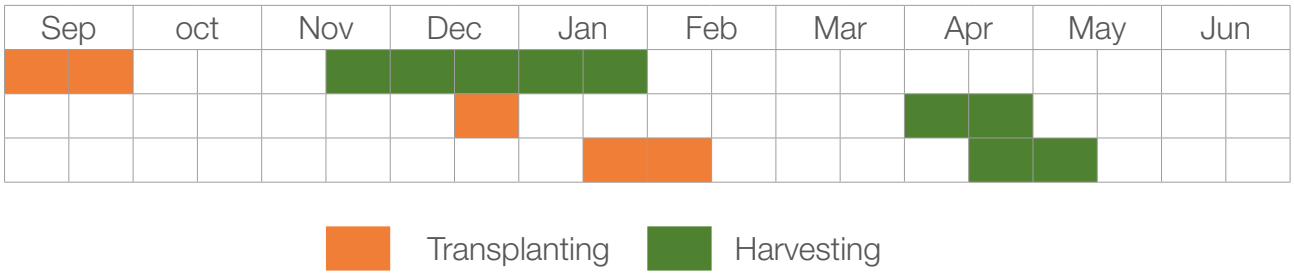
The first possibility: Cabbages are leafy vegetable which are low in calories, rich in fibre and high in vitamins A, E and C. Transplanting can take place in early September and, depending on the variety and length of the cycle, harvesting can take place from December to the months of March, April or even May. Among cabbages there are some innovations such as 'Broccolini', which is considered a superfood. The different shapes and colours of cabbages, can awaken the pupils' interest in this type of vegetable.

Source: Fundación Cajamar

For a broccoli plant to develop normally, temperatures need to fluctuate between 20 and 24 ºC during the growth phase; to be able to start the floral induction phase it needs temperatures of between 10 and 15 ºC for several hours a day.

The plant and the skin do not usually freeze at temperatures of close to 0 ºC, as long as it is only for a few hours a day.

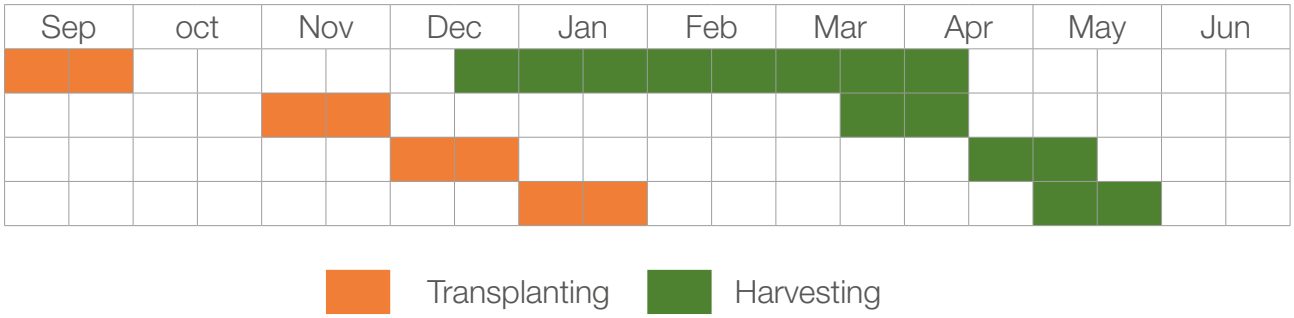
Production Schedule broccoli



Cauliflower is slightly more sensitive to the cold than broccoli and respond poorly to low temperatures (0 ºC). It is also affected by high temperatures (>26 ºC). The optimal temperature for the crop cycle is between 15.5 and 21.5 ºC.

Source: Fundación Cajamar

Production Schedule cauliflower

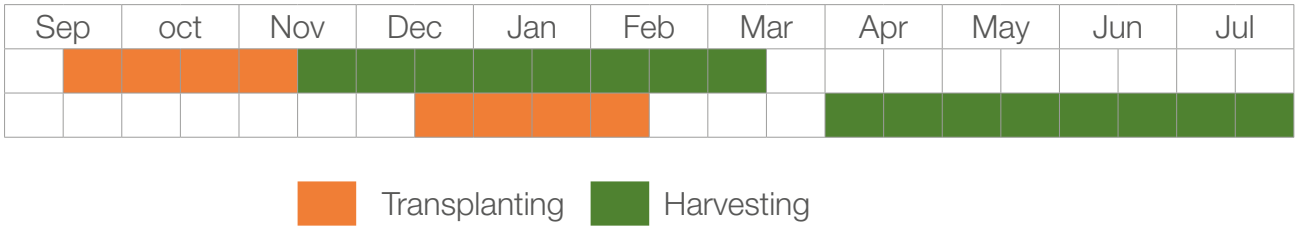


Cabbage and *red cabbage* adapt well to the climate. In general terms they adapt better to humid environments but are extremely sensitive to drought. In terms of temperature, optimal vegetation takes place at day-time temperatures of between 13 ºC and 18 ºC and night-time temperatures of between 10 and 12 ºC.

Some varieties can stand temperatures as low as -10 ºC, while spring harvest varieties vegetate well at high temperature. Exposure of young plants to low temperatures during a certain period may lead to premature flowering.

Source: Fundación Cajamar

Production Schedule cabbage



Artichokes

Secondly, another interesting crop are artichokes. The main production period along the Mediterranean coast is autumn and winter, usually starting in October it continues almost uninterrupted, in the absence of frost, until the end of May. Harvesting stops during the winter months in colder areas and is resumed in the spring.

Artichokes are high in vitamins C and B1. They have properties for diabetics, since it is hypoglycemic, it helps to regulate the liver and kidney functions. It is ideal for certain diets due to its low-fat content and vitamin balance, it is also rich in fibre, proteins and carbohydrates.

A well-known artichoke variety is 'Blanca de Tudela' (Tudela White). Propagation is carried out from cuttings, stumps or stalks.

Propagation from cuttings is the most common system. The cuttings are taken from stalks, which have produced artichokes, have dried and been cut, while the plant is dormant, about 5 to 10 cm from the ground. This cutting can be transplanted during August and the first days of September. It is also possible to acquire sprouting plants from a nursery.

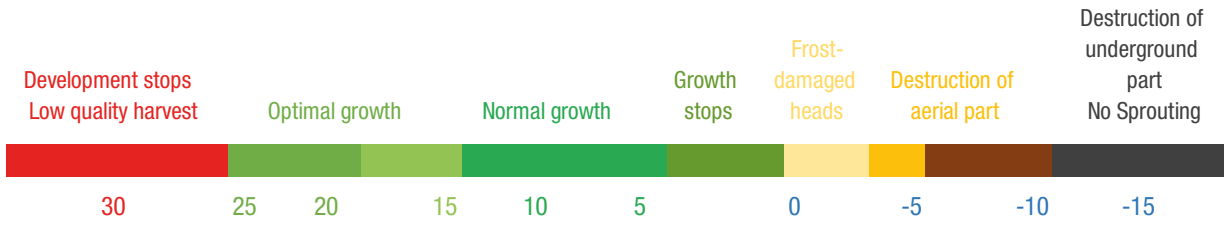
There are new artichoke varieties propagated from seeds. Sowing is recommended in late May or early June, and transplanting, when the plants have four to five leaves, in the second half of July or during August. However, these dates are not the best suited to the school calendar.

Artichokes are winter vegetables (cold season) and grow best at daytime temperatures of 24 ºC and night-time temperatures of 13 ºC.

The right temperature range for a good artichoke harvest is between 7 and 29 ºC, with no frost. This way proper vernalization takes place (flowering is induced by the cold). On no account should artichoke plants be exposed to temperatures below -3.8 ºC. They are easily damaged by cold weather, i.e., temperatures near or below freezing point (0 ºC).

Source: Fundación Cajamar

The Effects of Temperature on Artichoke Plants



Potatoes

Potatoes can also be a very illustrative crop to include in a school garden. It is an easy crop to grow, the pupils can learn about another way to propagate and the uses of tubers. It can be planted in January and February and harvested between May and June.

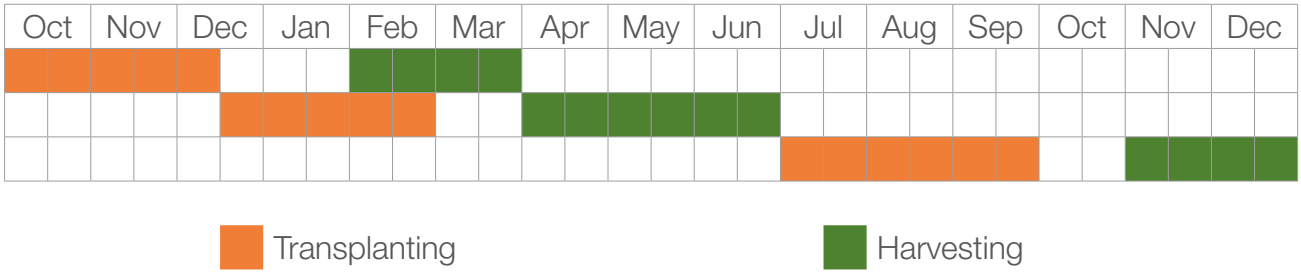
Source: Fundación Cajamar

Clonal propagation is carried out using seed potatoes (tubers). Tubers are endowed with growth buds (eyes) arranged in a spiral, and can be planted whole or cut, depending mainly on the size of the tuber. The smaller potatoes are planted whole, the medium-sized ones are cut in half and the large ones into four pieces.

It is a plant for temperate-cold climates and the most favourable temperatures for it to grow in are between 13 and 18 ºC.

For planting, soil temperature should be above 7ºC, with relatively cool night-time temperatures.

Production Schedule potatoes



Subperiods	Length (months)	
ºC	4	12
Latency	4	1
Apical Dominance	2-3	1
Normal bud	7	1-2

Peas

Peas are amongst other possible crops and which can be used in practical biology classes. Mendel used peas in his work that laid the foundations for plant breeding. This vegetable can be used for its seeds or complete with the pods with a variety known as ‘snow peas’ or ‘mangetout’.

Source: Fundación Cajamar

It is a crop which requires a temperate, slightly humid climate. The plant freezes at temperatures below -3 or -4 ºC. It stops growing when temperatures fall below 5 or 7 ºC. Optimal growth or vegetative development is at temperatures of between 16 and 20 ºC, the minimum being between 6 and 10 ºC and the maximum over 35 ºC. If the temperature is exceedingly high, the plant will vegetate quite badly. It needs ventilation and luminosity.

	ºC
Optimal Temp.	16-20
Max. Optimal Temp.	21-24
Min. Optimal Temp.	7
Cycle (days)	From February

Onions

Onions can be considered a feasible crop because it is also well-adapted to the school calendar. It is a clear example of a crop to be used for its bulb, it has nutritional properties and can be considered bactericidal and it can be sowed directly in the soil. There are farmers who grow the seed in the field, and others who prefer to plant the seedlings. Seedbeds are also produced in professional nurseries.

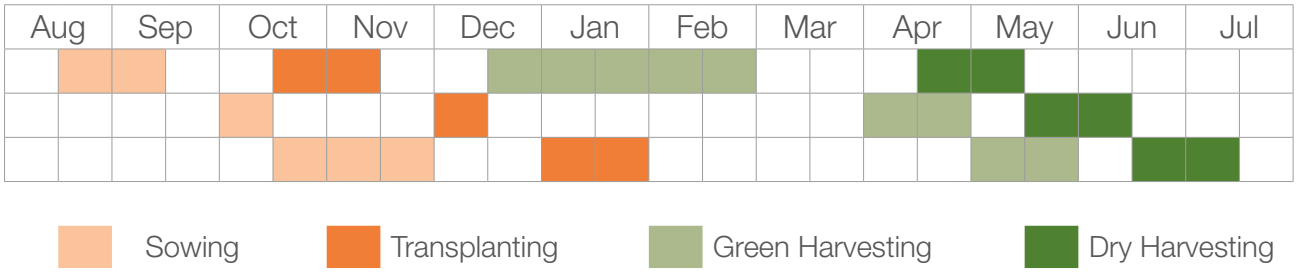
There are many varieties of all shapes and sizes, depending on what they are to be used for. The earliest varieties are sown at the beginning of September and harvested in April or May. Others are sown in mid-September for harvest in May and June. Finally, the later varieties are sown in November and December and could be harvested as tender, or green, onions during the school year.

Seeds can be germinated in substrate-filled trays. There are crops that adapt well to this type of growing, such as radishes, leafy crops, herbs and aromatic plants.

It is a temperate climate plant, and, although in the early stages of cultivation it can tolerate sub-zero temperatures it requires higher temperatures and longer days for the bulbs to form and mature. The early or shorter day varieties are ready to harvest in the spring, and the late or longer day varieties in the summer and autumn.

Source: Fundación Cajamar

Production Schedule onions



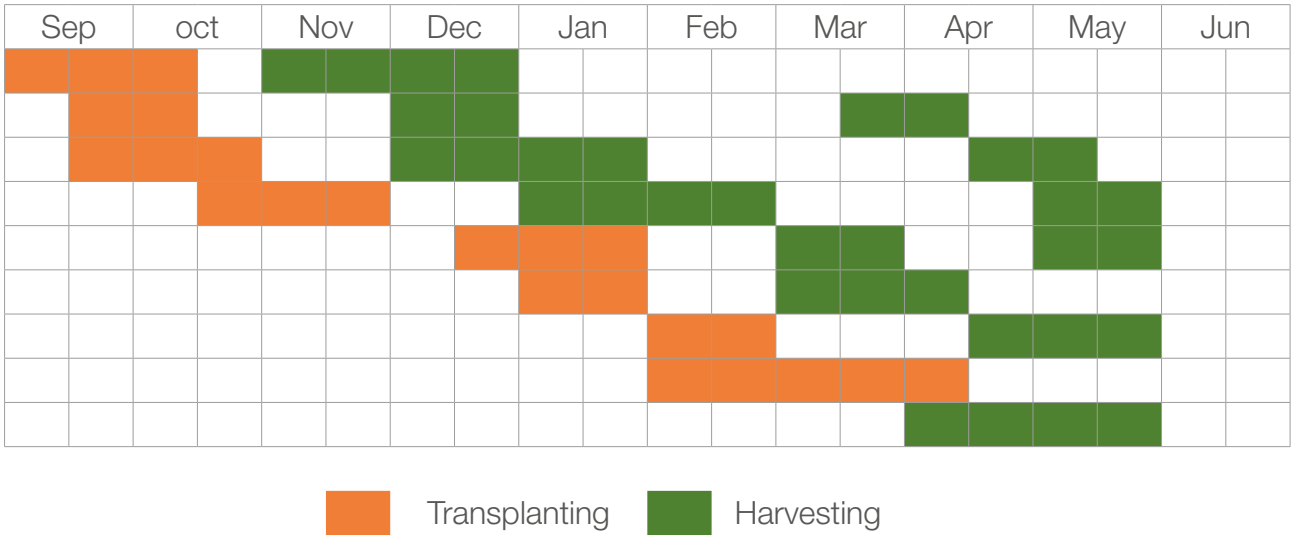
Lettuces

There is a wide range of types and varieties, all with different shapes and colours. They can be planted throughout the year and the weather conditions determine the length of the crop. They can also be grown in trays. Leafy varieties, known as baby leaf, are marketed as freshly-cut, ready-to-eat produce.

Source: Fundación Cajamar

While the crop is in the growing stage it requires different day and night-time temperatures of between 14-18 ºC during the day and 5-8 ºC at night. During sprouting it requires around 12 ºC during the day and 3-5 ºC at night. This crop is less tolerant to high temperatures than low ones. The maximum temperature it can stand is 30 ºC and lowest -6 ºC.

Production Schedule lettuce



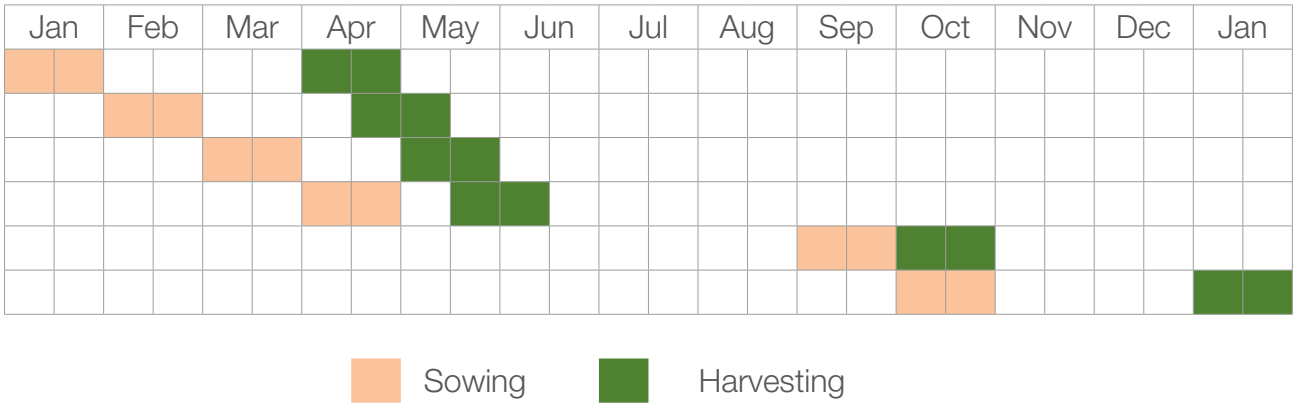
Chard

Another possibility is growing chard. It is an easy crop to grow and can sprout repeatedly and so, will last throughout the school year. Chard can be sown directly or planted as seedlings.

Growth stops when temperatures fall below 5 ºC and below -5 ºC the plant freezes. It grows well in temperatures of between a minimum of 6 ºC and a maximum of 27 to 33 ºC, the optimal average is between 15 and 25 ºC. Germination temperatures are between 5 ºC minimum and 30 to 35 ºC maximum, the optimum being between 18 and 22 ºC.

Source: Fundación Cajamar

Production Schedule chard



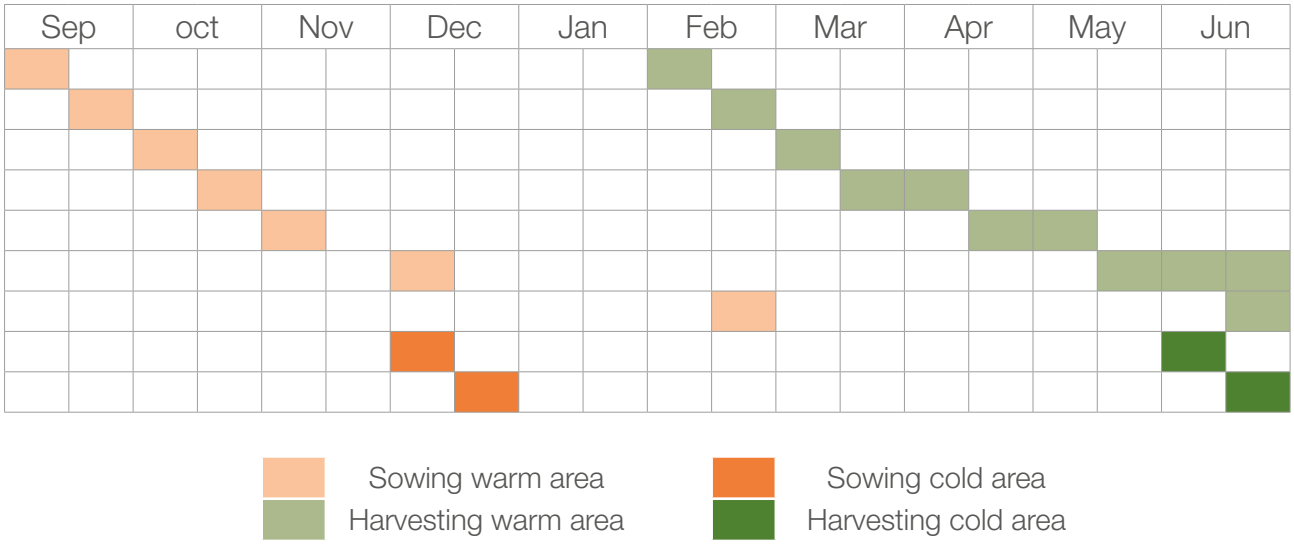
Carrot

Finally, an interesting crop is carrots, in which is usually sowed directly. The minimum growing temperature is around 9 ºC with an optimum of around 16-18 ºC. It can stand light frost; at rest the roots are not affected until temperatures drop to -5 ºC, which allows them to be kept in the soil. High temperatures (above 28 ºC) cause an acceleration in the root's aging processes, decolouring, etc.

There are many crops such as tomatoes, peppers, melons and watermelons which are suitable for their fruit. However, they are not the most appropriate for the school calendar, because their harvest period occurs during the holiday season.

Source: Fundación Cajamar

Production Schedule carrot



Seedbeds

Once the crop we are going to work with has been chosen, it is time to prepare the seedbed. There are different sized seedling trays depending on the plant. The trays are to be filled with a peat, coco fibre-based substrate or a mixture of both.

These substrates do not provide the plants with the nutrients they need. It is therefore recommended to prepare a 25 % compost / 75 % peat mix, ideally on the school grounds. The trays could be hand made from recycled materials, such as plastic yogurt cups, or any other similar type of container. It is important that there is a hole in the bottom of the container to ensure drainage.

Source: Fundación Cajamar

Prior to sowing, a small hole is made in the substrate of between 1 to 1.5 cm, into which the seed is dropped, and subsequently covered with a little vermiculite or leftover substrate.

Next it is important to water the substrate to ensure good germination conditions. To improve this, the trays can be taken to an enclosure with good temperature conditions and sufficient light.

Another possibility, if you want or need to jump the seedling phase, is to acquire the plants from a professional nursery, a garden center or other. This option is recommended when the sowing dates coincide with summertime or other holiday periods.

Source: Fundación Cajamar

5

Inputs:
Nutrient Requirements, Manure and Composting

5.

Inputs: Nutrient Requirements, Manure and Composting

Soil fertility is understood to be its ability to supply plants with each of the nutrients needed, whenever needed, in the right quantity and in a assimilable form. To carry out the physiological and metabolic processes that allow them to develop, plants need to take up a series of essential elements from the environment. Slightly more than fourteen chemical elements are essential for plant development: germination, growth, photosynthesis, and reproduction. Every nutritional element plays a specific role in plant nutrition. For example, the role that the three most important elements in any crop play in plants is explained as follows. Although, apart from nitrogen, phosphorus and potassium, which are the nutrients a plant needs in the greatest quantities, it also requires calcium, magnesium and sulphates. Plants also require microelements such as: copper, zinc, manganese, iron, chlorine, sodium, boron, molybdenum, although, as the word implies, they need them in minute quantities.

Nitrogen, a factor of growth and development

Nitrogen is one of the constituent organic compounds of plants. It is involved in cell multiplication and is considered a growth factor; it is necessary for the formation of amino acids, proteins, enzymes, etc. Nitrogen deficiency significantly affects plant development. This becomes apparent, firstly, in the old leaves, which become chlorotic from the tip extending completely through the midrib. The leaves acquire a yellowish-green colour and in the most severe cases the plant withers and can die.

Phosphorus, a factor of precocity

Phosphorus stimulates root development and favours flowering and fruit set, it intervenes in the transport, storage and transfer of energy and is present in phospholipids, enzymes, etc. It plays a role in precocity since it activates the initial development of crops and favours ripening. A lack of phosphorus leads to weak development of both the aerial part and the root system of a plant. The leaves become thinner, erect, with less pronounced veins and be dark green / blue in colour, they may even fall prematurely.

Potassium, a quality factor

In plants, potassium is very mobile and plays multiple roles. It improves photosynthetic activity; increases a plant's resistance to drought, frost, and disease; it promotes lignin synthesis, favours plant rigidity and structure, the formation of carbohydrates in the leaves and participates in the formation of proteins; it also increases the size and weight of cereal grains and tubers. Potassium deficiency causes a general delay in growth and an increase in a plant's vulnerability to possible parasite attacks.

It also makes its presence felt in a plant's storage organs: seeds, fruits, tubers. If there is a marked deficiency, chlorotic spots appear on the leaves which also curve upwards. Correct potassium fertilization improves the uptake and efficiency of nitrogen fertilizer.

Composting

Composting transforms the organic part of waste into a natural fertilizer, thus closing the organic waste cycle, preventing it from ending up in landfills or incinerators since this gives rise to certain associated problems:

- Organic matter in landfills: The decomposition of organic matter in landfills produces biogas, which contains carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), pollutants that contribute to intensifying the concentration of greenhouse gases in the atmosphere which leads to environmental problems. Furthermore, it can contaminate groundwater or soil through leaching.

- Organic matter in incinerators: The objective of waste incineration is basically to reduce its volume and hazardousness. This combustion process generates an extremely high amount of greenhouse gases, heat and ashes which are highly toxic.

Source: Gettyimages

A sustainable solution is the process of composting organic matter. Thanks to this process, up to 30 kg of compost can be obtained from every 100 kg of organic matter. This contributes to the reduction in the waste arriving at landfills and incinerators. It also reduces greenhouse gas emissions and, at the same time, the consumption of chemical fertilizers in crops.

What is Compost?

Compost is the result product obtained from the natural phenomenon of organic matter decomposition. It is carried out by a series of microorganisms in the presence of air and moisture. It is a sustainable solution since thanks to this process, up to 30 kg of compost can be obtained from every 100 kg of organic matter.

During composting, a wide variety of microorganisms feed on the nitrogen and carbon (And other macro and micronutrients) contained in any organic matter and consequently reduce the size of what they eat while changing the original properties of colour, texture and composition until a dark-coloured substance of a texture similar to garden mulch, with the ability to feed plants, is produced.

In addition to being a food for plants, compost can improve soil texture, soil aeration and maintain microbial life. It is therefore a product with intermediate properties between the manure and the soil itself.

As with manure, it provides nutrients but unlike manure, it is not a potential source of excess nitrogen. It is gentle on delicate plants and allows them to grow directly in it as they do in soil.

Since composting is a natural process in which microorganisms eat organic matter, the resulting characteristics of the compost are not unique. Depending on the initial composition, the climate, the moisture conditions, together with degree of aeration maintained and the duration of the process, the final product will resemble a fine substance with the typical smell of wet soil, or one which is not so homogeneous with pieces several centimetres long and a slightly stronger smell.

How to Make Compost

The simplest way of all consists of piling up a certain amount of organic matter into a heap on the ground. The amount to be piled up is relevant because a small heap of less than one hundred litres is not sufficient to create the conditions to start and maintain the process.

Source: Gettyimages

For this pile of waste to turn into compost, it is necessary to ensure that the organic matter has a carbon and nitrogen mix, which is essentially food for the microorganisms.

As a rule, all green matter and products that rot easily, such as fish, food scraps, etc., are rich in nitrogen, while those that do not rot or smell, such as wood, sawdust, dry leaves or paper, are a source of carbon.

A compost heap should balance the waste content until it reaches an ideal mixture of 30 parts of carbon to one of nitrogen.

While "feeding" microorganisms use carbon both to create their cells and as an energy source. In the process we call metabolism, the microorganisms' breathing returns some of the carbon as CO_2. For every thirty parts of carbon used, ten are incorporated into their cells and twenty are "breathed out" in the form of CO_2. They add one part of nitrogen for every ten parts of carbon they digest.

If there is excess nitrogen in the pile, the microorganisms will release it in the form of ammonia, which is the typical strong smell of rubbish bins or unbalanced compost piles.

If there is an excess amount of this gas it will asphyxiate many of the bacteria, which need oxygen, thus possibly stopping the process.

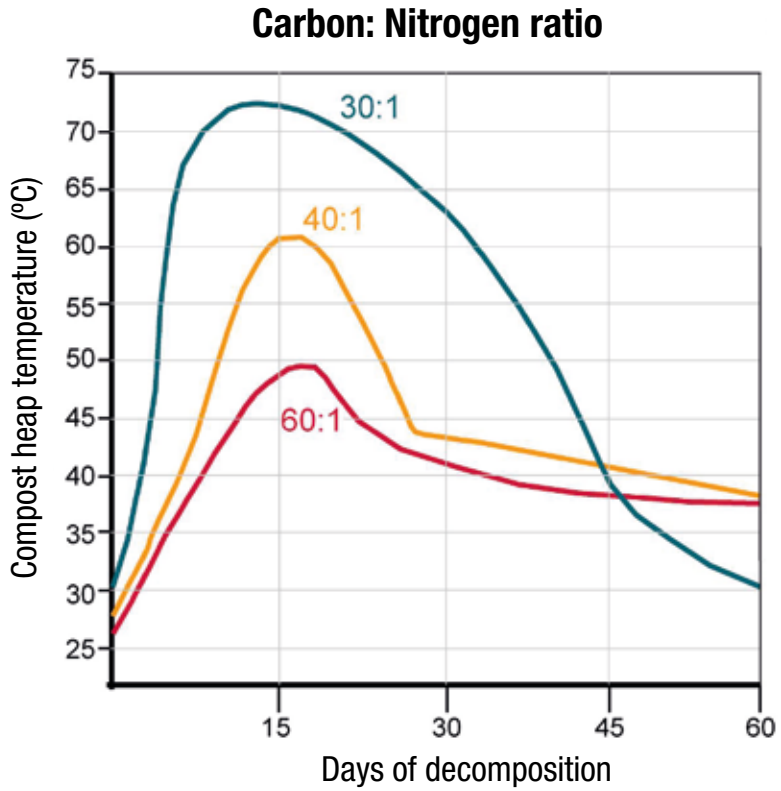
If, on the other hand, the heap is lacking in nitrogen, the starting process, which is quite noticeable because it reaches temperatures of over 60 °C, either slows down or does not even reach more than a few degrees above the surrounding temperature.

Source: Gettyimages

Influence of C/N ratio on composting

- Carbon: Nitrogen ratio
- Compost heap temperature
- Days of decomposition

Hence the importance of preparing a balanced recipe and thus achieving a pile that will have nothing whatsoever in common with the idea of a pile of rubbish.



Besides the type of food, the microorganisms will need air and moisture so the pile will have to be watered and aerated. The first is carried out at the beginning and is monitored over time without requiring much more water than that which was originally added. The composting itself produces liquids that keep the pile at an ideal level of moisture, which feels moist to the touch but if squeezed, does not drip. If there is a insufficient, or excess, moisture the process will slow down or even stop.

Although water is important, air is even more so, as microorganisms can only work in well-aerated conditions. If the heap is a block that we don't turn over or aerate in any way, the bacteria will use up the initial contents and then stop.

If there is organic matter and a lack of oxygen, we are paving the way for other types of colonies: those that live in the absence of oxygen and which, instead of producing humus, generate unusable products, bad smells and gases such as methane.

The key to any good composting process is to aerate the pile and there are many ways to achieve this. Fork the pile over from time to time, or poke holes in it with a stake, put in static chimneys to induce certain natural air currents, or even use a compressor to inject air.

What to Add and What Not to Add to Compost?

There are many more products that can be added to compost than can be listed, but the following are some examples of compostable and non-compostable waste.

Composting materials

From the kitchen

Can be added	Can be added in small quantities (always crushed)	Avoid adding
Fruit and vegetable waste	Bones and shells	Meat and fish waste[a]
Stale bread and cooked scraps of food	Corks	Dairy products
Coffee grounds and tea leaves		
	Citrus peel	Products containing yeast and fat
Crushed eggshells		
	Paper napkins, paper bags and paper packaging	Products containing salt or seasoning
Dry fruit	Fruit stones, pips, seeds and peel	

[a] *It is advisable not to add cooked and fatty products, especially meat and fish.*

Origin: Orchard or garden

Can be added	Can be added in small quantities	Should be avoided
Wilted flowers and sticks	Sawdust from untreated wood	Animal excrement
Green or dry leaves	Ruminant manure (Sheep, goats…)	
Grass and other herbaceous plants[b]		
Pruning waste and shredded branches		
Orchard / Garden waste		
	Paper napkins, paper bags and paper packaging	Products containing salt or seasoning
Dry fruit	Fruit stones, pips, seeds and peel	

[b] *Care must be exercised with fresh grass cuttings due to its high content in water. To avoid this, it should be well mixed straw or hay or left to dry previously.*

Non-compostable waste

• Cigarette filters	• Non-organic materials (plastics, glass, metal, rubber...)
• Nappies / Diapers	• Sawdust from treated wood or chipboard
• Glossy magazines	• Non-biodegradable waste
• Vacuum cleaner waste	• Special waste
• Synthetic clothing materials	

Precautions During Composting

Once the heap has been made, the mechanism starts almost immediately with a phase in which a lot of heat is generated in the centre. Temperatures normally reach between 60 and 75 °C for several days. However, temperature is not uniform throughout all the compost heap and the process can take some days. Therefore, if too much food waste has been added, sooner or later the compost heap is going to attract flies and even mice.

Total control is impossible, and it is not possible to mitigate its effects much. However, covering the heap with as much sawdust or dry leaves as possible is a barrier to flies.

As long as the heap is at a temperature that will deter flies, the sawdust barrier is effective. When the process is underway and the heap starts to work, the heat itself will keep the flies under control, but only if it is working well. If it is unbalanced or lacks aeration it will smells and the heap will attract unwanted 'visitors'.

Once the process is underway, neither the temperatures nor the product will be to the liking of mice. But if the presence of flies and mice is to be avoided even further, the next step is to compost not in heaps on the ground but in containers. Nowadays, there are containers of the type used to collect household waste that are sold as composters.

If the heap is large or you do not want to follow the commercial model, the most widespread option is to build wooden crates. Wood has the advantage of being a natural product and can be built with removable sides so that even if the box is large, one of its sides can be removed and the pile can be left open both for aeration and emptying.

Source: Gettyimages

In a container the only part exposed to the air is the top and therefore it is much easier to control. Common practice has shown that a well-managed compost pile inside a compost bin or box is not only odourless but does not attract a particularly troublesome amount of flies.

As the compost heap is a fully operational waste disposal machine, there is a tendency to add weeds or any other products that get in the way. Although well-functioning composters stay at temperatures of around 65 °C for many days at a time, causing common seeds and pathogens to die, composting should not be considered a sterilisation system.

Not all the heap reaches that temperature and inevitably there are parts which may still contain seeds or pathogens even if they are composted. That is why it makes sense not to add anything to the heap that we would not like to spread.

Source: Gettyimages

A common concern for gardeners and farmers alike is the possibility of transmitting fungi, viruses and other plant diseases through the compost. The experience acquired by compost producers the world over during half a century shows that compost is a source of health for the soil and plants and the degree of inconvenience caused to those who have suffered this problem is merely anecdotal and does not justify stopping its use. This is especially so because it has often been shown that the problems caused were due an inadequate composting process rather that the use of the compost itself.

How to Make a Proper Compost Heap?

The recipe for combining nitrogen- and carbon-rich materials requires the stockpiling of sufficient quantities of both types. Once this has been done, a heap with alternating layers of both materials is piled up.

Storing carbon-rich material is easy as there are no visible reactions such as smells or leaking liquids. Of all the possible types of materials, the most convenient is sawdust. The same applies to wood shavings and dry leaves, although they take longer to decompose and, depending on their size, will still be recognisable as such when the rest of the material has become a homogeneous, dark-coloured mass.

Storing the nitrogen-containing material is more complicated. No matter how little we pile up, there will almost certainly be odours and leachate, and these drawbacks need to be dealt with. One effective way is to store the material in layers separated by other layers of sawdust.

In the case of using materials such as food waste or animal manure the system will require a generous layer of sawdust at the bottom to absorb most of the leachate produced. The layers of the nitrogen-source material are then interspersed with layers of sawdust and topped with an equally generous layer of sawdust.

If the organic matter added is relatively dry, the system will be able to remain odorless and non-composted for months in winter conditions and for weeks even in the full heat of summer.

Regarding home composting, a family of four will have to accumulate between fifteen to twenty medium-sized bags of household waste to have enough to start a composting system. The storage system previously mentioned will prevent the smell of the waste being noticeable during the several weeks the process will take.

In the case of larger scale processes, the model works the same except that instead of accumulating bags of waste containers or heaps are needed. In these cases, it is necessary for supplies to be kept out of the rain. A little water will not affect it but water in excess, due to heavy rainstorm or many frequent showers, will ruin the process as composting may begin and, as it cannot continue, the type of waste produced can be difficult to manage.

Source: Gettyimages

How to Prepare the Waste

Composting is a process that takes place on the surface of a material, therefore the larger the surface area provided the greater the efficiency and speed. Any food waste or animal manure is usually sufficiently disintegrated to be used as it is.

Agricultural waste needs certain attention. An allotment or garden usually produces two types of waste. One while the plants are growing and another when they are pulled up. In the first case, any prunings, broken or discarded fruit can usually be used directly. When the plants are pulled up there is usually a large amount of material available and the pieces are woody and of a considerable size.

This type of waste cannot be composted as it is, and there is no option but to shred it into pieces no longer than 6 to 8 cm. There are many types of shredders, but none are suitable for all types of waste. Most woody materials can be shredded with machines known as bio-shredders but when the product is wet and fibrous, this type of machine can jam.

Lawnmower type machines can take care of more humid material but, on the downside, cannot handle particularly tough material or waste containing soil or stones. Other solutions include hedge trimmers and, if a tractor is available, a rototiller that crushes the product without adding it to the soil.

Shredding the product is undoubtedly a complex process that takes time and money but there are other advantages than simply accelerating the composting process. Any shredding system used will reduce the initial volume by half or even more. What at first might seem like an undigestible mountain of waste, turns into something much easier to collect and, of course, to process.

How to Make a Compost Heap?

In principle, making a small hill out of organic matter does not appear to be a task requiring much of an explanation. Even if it is not particularly difficult, it is worthwhile considering some ideas beforehand that will avoid problems later.

A compost heap is started by piling up interspersed layers of carbon-rich matter with others rich in nitrogen, until the ratio is about thirty of the former, to one of the latter. Precise calculation is no of the essence here as common sense is the best guide to follow.

Leaves and other plant waste are not all nitrogen, even if they are green. In fact, if we let them dry out, they fall into the category of carbon storage. A pile of green leaves, vegetable waste, etc. can be composted as it is, a little dry matter can be added, and the heap should start composting without much trouble.

If the basic product is food scraps from a bar, slurry from a farm or some similar product, the situation changes radically. This is almost pure nitrogen to which a lot more carbon will need to be added.

Once the availability of the products has been assessed, these must be analysed. The compost heap will need to be aerated, wetted from time to time and, at the same time, it will also have to be protected from waterlogging due to excess rain, as well as being monitored for a period which can vary between four and six months.

A space with adequate access for the initial materials and to remove the finished compost is required. It must also be wide enough for aeration. If the heap is small, with a base to two or three metres and one or one and a half metres high, it can be aerated by pricking it using a pitchfork or a shovel. But if the heap is bigger then there is no choice but to turn it over completely, and that process requires space.

A medium or large heap, a row two to three meters wide by dozens of meters long and a height of one or two meters, cannot be turned by hand and will require the use of a tractor or similar machine, which again will need space to manoeuvre.

Since compost retains moisture very well and does not need to be watered often, moisture control can be carried out using a hose. It may be necessary to wet the heap once a week due to evaporation if composting is taking place in mid-summer, in an extremely hot area and in direct sunlight. As an outdoor heap is exposed to rain, rainfall should also be considered. Five to ten mm of rain will not affect the heap and may even compensate for the evaporation mentioned above. However, larger rainstorms can waterlog the heap, it is therefore advisable to be aware of the weather. If more than 10 mm per day of rain is expected, or several days of rain are forecast, the material should be completely covered with plastic sheeting.

Once the heap is completed, composting will start from the inside, whatever it contains will reach temperatures of over 60 ºC and the volume of the heap will decrease notably. It is important to aerate the heap and mix the different layers so that all the material passes through the centre of the heap, the focal point of the microbiological activity, and decomposes homogeneously.

Each time the layers are mixed, turned over or generously aerated, the heap cools down to between 5 and10 °C but, if there is fresh organic matter, the heating process will restart. If no further matter is added, the initial part of the heap will have been consumed within four to six weeks and then the compost heap will already be a dark in colour. The interior temperature will be 30 to 40 ºC and it will be very difficult to identify what was added at the beginning.

This product needs to mature, almost like wine, and let other types of microorganisms different to those in the initial phase generate the humus which is the characteristic quality of compost. The aging process can take from three to six months depending on the outside temperature and the care taken to maintain the moisture and oxygen levels in the heap.

During this aging process, the matter in the heap continues to disintegrate, the pH changes from a basic initial level to neutral or slightly acidic and the smell in the interior becomes that of moist soil.

If there is a smell of rotting or ammonia coming from the heap, it is a sign that it is not aerated. The lack of air during a short period of time, a few days or even a couple of weeks, may not be serious, but if the heap lacks air for months, it is more than probable that the colony of good microorganisms will be decimated, and more harmful ones attracted. That way, when we attempt to restart the process the heap will not react, and we will be left with a half-finished product that should not be added to the plants.

On the subject of moisture control, the necessary measures must be taken to prevent the heap from becoming waterlogged. Any of the heaps described above left out in the open in the rainy season end up getting waterlogged and impossible to control. If the composting is not done in containers or inside a warehouse, the pile will have to be covered with plastic sheeting.

How to Monitor the Heap

The two simple systems for monitoring the compost heap process are temperature and odour. It is also important to monitor the moisture volumetric content of the head and that it remains around 40 %

Under normal and optimal conditions, the heap should not give off an unpleasant smell, but if by some chance one of the parameters has become unbalanced, the smell may appear. As a rule, the smell will indicate insufficient oxygenation. However, if this is not the case and the heap smells of ammonia, then there is an excess of nitrogenous product and sawdust or a similar material must be added.

Temperature is the most typical parameter used for monitoring compost and this can be done using a simple thermometer.

The so-called thermophilic phase takes place during the first days. The first microorganisms to get to work have a voracious appetite, they eat the added matter very quickly and generate a lot of heat. The temperature is usually measured internally, and it is normal for temperatures to reach more than 50 ºC after the first day and 65 or 70 ºC a couple of days later. Higher or lower temperatures depend partly on the outside temperature and the type of matter used. In cold places, with a limited supply of nitrogen, temperatures do not normally rise above of 50 ºC while in summer they can reach 70 ºC.

Although there is some leeway when it comes to determining whether the right temperature has been reached, what is essential is that that temperature is maintained for a minimum period of between two and four weeks.

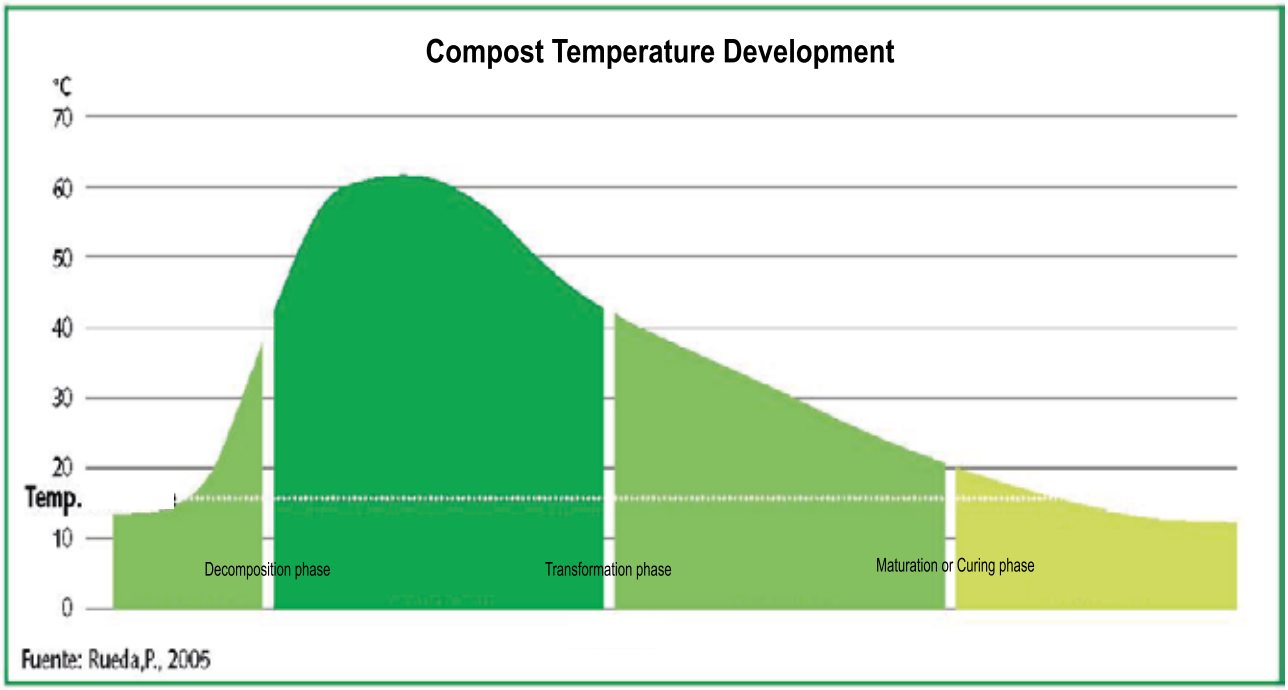
The thermophilic phase is not only necessary to prepare the matter for the next colony of microorganisms which will be dedicated to making the products of the quality that plants require to grow well and the soil to be healthy, but also to kill most of the pathogens that may have been present in the first place. The seeds of the composted plants are also included in the group of undesirables to be eliminated. Both will disappear almost completely as long as the heap is kept at around 50-60 ºC for enough days.

In addition to temperature, leachates and many acidic elements are produced and both the liquid that exudes from the pile and the heap itself will have a pH lower than 6 during

the thermophilic phase. After the first few days of a clearly acidic pH, the heap evolves towards a basic pH, rising rapidly to values of 8 or 9.

Once this phase ends, shown by the fact that the thermometer which suddenly rose to around 65 ºC, remained there for some days and then dropped rapidly until levelling off at around 40 ºC, the bacteria that take over cannot live in a basic environment and the pH begins to drop.

During the entire maturation or curing period in which the temperature is to be maintained between 30 and 40 ºC, the pH will gradually drop to values of around 7 or 8. The closer to 7, the better the maturation process has evolved.



If a chemical analysis is carried out and the standard parameters measured, the data on organic matter and humus content will tell us the compost is ready.

Other important data are the right maturation/curing, salinity, and pH levels. When these conditions have been met the compost is considered able to make seeds germinate. A widely used quality parameter is to achieve greater than 90 % germination of 'Raygras' seeds.

What are the Characteristics of well-made Compost?

Compost is considered to be good quality when it nourishes the plants and enriches the soil. However, not all plants have the same requirements nor do all soils have similar properties. Therefore, a list has been drawn up containing a wide range of values to be analysed and which are identified with the nutritional properties of the fertilizers.

Compost quality requirements are designed to ensure acceptable appearance and smell, adequate cleansing, a limit on trace levels of impurities and pollutants, a desirable level of agronomically available elements and the characteristics of homogeneity and uniformity enabling it to be stored without subsequent alteration. The governing bodies are not as well synchronised as those regulating traffic and there is no single universal definition except for the aspects relating to health and safety guarantees.

Taking pathogen control for granted, it is at least in line with Royal Decree 824/2005 of 8 July on fertiliser products; Order APA/863/2008 of 25 March. (Salmonella: Absent/25g product, Escherichia coli: <1000 NMP/g product, those contained in the RD 2071/1993 of 26 Nov. in the Law 43/02 on Plant Health and in the Order 776/02 of the Ministry of Agriculture, Fisheries and Food (MAPA), the quality measures presented in the following table are a summary of the requirements published by some of the international associations dedicated to compost or by the regulatory bodies dedicated exclusively to composting.

Source: Gettyimages

Measurements are generally grouped into three types of parameters

Parameter	Ideal Value	Comment
Physical		
Particle size distribution	Passes through 8 mm sieve	
Apparent density	600 Kg/m^3	It can vary by 25 % depending on the initial product or the state of maturity.
Inert material	< 8 %	May include a maximum of 5 % stone / sand and a maximum of 3 % of plastic and metal.
Moisture	40-50 %	Even for very mature compost moisture should not be lower than 30 %.
Chemical		
pH	6.8-8	The source material influences the pH. If the main product is leaves, the final value is more basic and if manure is applied, it acidifies. As it is then applied to the soil, the influence of the pH is balanced with that of the soil and the amount to be used.
Electrical conductivity	3.5-6.4 mS/m	Indicates the amounts of soluble salts among which there are chlorides or sulphates which are harmful to plants. The optimal limit is set by the application. Delicate plants or seedbeds cannot take values higher than 2.5 while many others thrive at values of 6.
C/N	10-14 %	
Organic matter	35-70 %	
Humic acids		
N (total)	1-2.5 %	This is the sum of inorganic nitrogen in the form of nitrates and organic nitrogen embedded in the organisms present. The latter must decompose to produce the inorganic (nitrogen) phase which is absorbed by the roots.
P (P_2O_5)	1.5-2 %	
K	1.5 %	

Parameter	Ideal Value	Comment
Chemical		
Ca	2 %	
Mg	1-1.3 %	
Heavy metals	(mg/kg of Organic amendment)	
Arsenic	41	Many plants are more sensitive to heavy metal toxicity than humans. Limits are set both to avoid problems for the plants as well as possible transmission to humans through food. The values tend to be reduced should a problem, in which there are signs that the compost may be the source, arises.
Cadmium	2	
Copper	300	
Nickel	90	
Lead	150	
Zinc	500	
Mercury	1.5	
Selenium	100	
Chromium (total)	250	
Organic and Biological		
Biological	(UFC/g)	
Total bacteria	$133 \bullet 10^7$	
Actinomycetes	$41 \bullet 10^4$	
Fungi	$48 \bullet 10^3$	
Nematodes	Absent	
Maturity index	> 95 % germination	Amongst the different measurement systems available, seed germination (radish and grass) was mentioned.

Compost as a Fertilizer

Compost is the product resulting from carrying out the entire composting process correctly. Mature compost is characterized by its dark brown or black colour. It must give off a smell of moist soil and the remnants of food or original plants contained in it must not be distinguishable. It must be completely integrated, its texture spongy and not stain the hands.

Source: Gettyimages

The use of compost as a fertilizer in agriculture is of great interest, since the presence of this product in the soil in appropriate proportions is essential to ensure its fertility and prevent desertification. It also has the following characteristics that contribute to plant growth and development:

- It contains a series of macro and micronutrients in the form of chemical complexes that enable the plants to assimilate them.

- It increases water retention capacity, enabling less frequent watering and, at the same time, facilitating drainage, leading to better drained soils. In other words, it makes clayey soils more permeable and sandy soils more absorbent.
- It increases porosity, obtaining lighter soils that enable the flow of air and oxygen.
- It favours seed germination.
- It regulates and promotes the activity of beneficial microorganisms for plants.

Therefore, composting not only reduces the amount of organic waste in landfills, but also benefits soil fertility and the natural growth of other plants.

Both orchards and gardens need compost to renew the substances that the plants have absorbed during growth. To apply compost, only mature compost should be used to ensure slow and continuous absorption of nutrients as rain or watering occur.

In the garden: Approximately one to three kg of mature compost is to be applied per square metre, between one and two months before planting the vegetables.

Lawn: When regular mowing starts, i.e., in the spring, apply a layer of between one and two cm of mature compost to the lawn using a sieve so as not to hinder the growth of the grass.

Ornamental trees: To compensate for the effort made by the tree in spring and summer, about two cm of compost is applied during the autumn to the entire surface area of the ground covered by the canopy of the tree.

Plants and flowers: During the spring they require about two cm of compost together with the garden soil.

Seedbeds: Mix equal parts of mature compost with soil and sand. It will provide assimilable nutrients for the plants.

Pot plants: Mix mature compost, topsoil and pearlite in equal parts. It will provide assimilable nutrients for the plants.

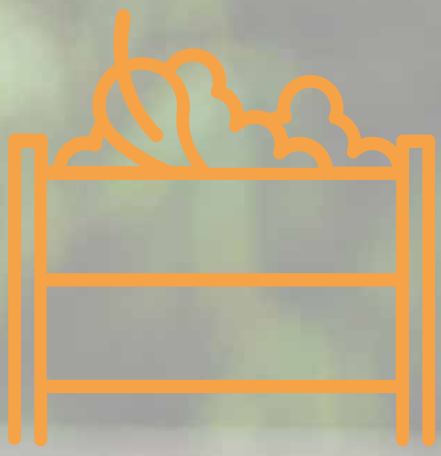
Use of Plant Waste

Once the crop is finished and harvest completed, the plant waste must be managed. Since vegetable waste contains nutrients and can improve soil structure, instead of considering crop waste as something to be removed, it can be used so reducing wastage at the same time. This agricultural practice is intended to return the remains of each harvest to the soil to improve organic matter levels and the fertility of the soil itself.

Crop residues have a high moisture content and are generally easily degradable. They can also be incorporated into our composter along with the rest of the ingredients that we have.

Source: Gettyimages

How to make Compost



1 Choose a place

Where piling up a certain amount of organic matter into a heap on the ground

2 Add the ingredients

3 Add Water if needed

4 Aerate and Mix the different layers

5 Wait a While

6

Planting & Semi-protected systems

6.

Planting & Semi-protected systems

Plot preparation, planting, direct sowing or planting of cuttings

Regarding soil preparation it is important to ensure good drainage and to dig and loosen up the soil, for the seeds and plants to root well as well as to be able to dig furrows or make the raised beds on which to work.

It is important to incorporate the nutrients prior to planting. Although there are mineral fertilizers, for the school garden we recommend of organic fertilizers or the production of compost in the school itself.

Composting is a technique which makes use of the organic waste produced by society for it to be used to improve the organic matter content of agricultural soils. Composting is a process that enables the stabilization and cleansing of organic waste, while it can be used to improve agricultural soils, so avoiding its destruction, incineration or use as landfill. When compost is obtained from an adequate combination of waste, it can give rise to an organic product with excellent properties for agricultural use. The use of this system in schools would enable the pupils to understand the concept of the circular economy.

Source: Gettyimages

Compost can be added to the garden with a rotavator or cultivator or, if this is not possible, it can be done manually using tools such as mattocks and rakes, in order to also leave the soil loose and ready for sowing or planting.

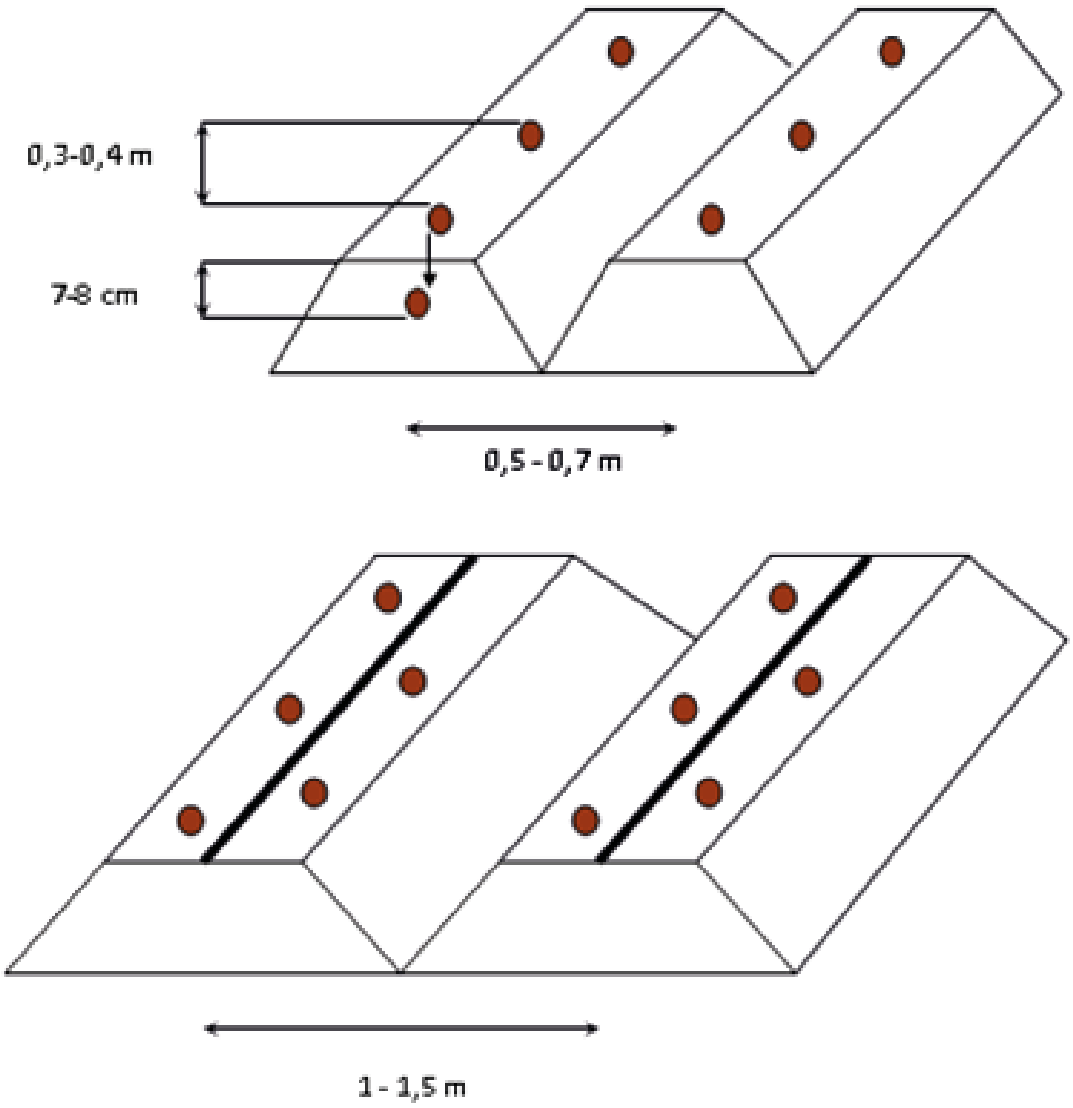
Although it is not totally necessary, it is advisable to mark a straight line and make small groove along it which will later be used for sowing or planting.

When designing a garden, it is important to take into account the distance between plants and between rows, this is known as plant spacing.

Although the size of the plot is a limiting factor, it is recommendable to use one row per crop and plant on the same date. If the plot is long, it can be divided into two halves each with its own independent irrigation system, depending on the crop or planting date. It is important to establish a crop programme and planting dates, together with a small plan, for the proper management of soil availability and also to facilitate the installation of irrigation.

The following are typical plant spacings for several crops.

Potatoes. The tubers are planted at a depth of 7 to 8 cm and between 0.3 to 0.4 m apart. The furrows are dug between 0.5 and 0.7 m apart. In this case we will make a slightly deeper furrow, to ensure the tubers are well buried. A wider raised bed can also be used, and the seed potatoes can be arranged in staggered rows, to subsequently ensure better irrigation distribution.

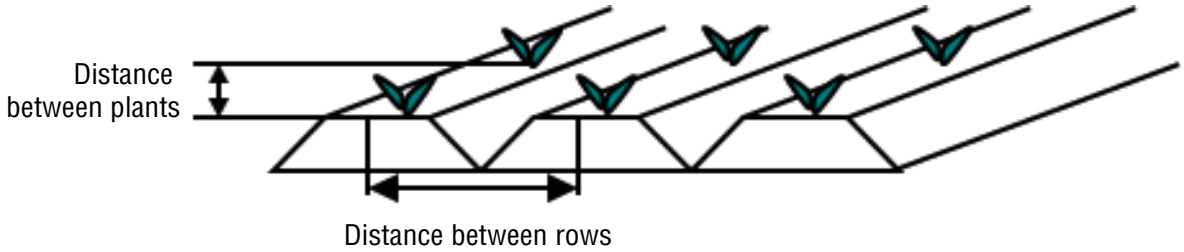


Source: Fundación Cajamar

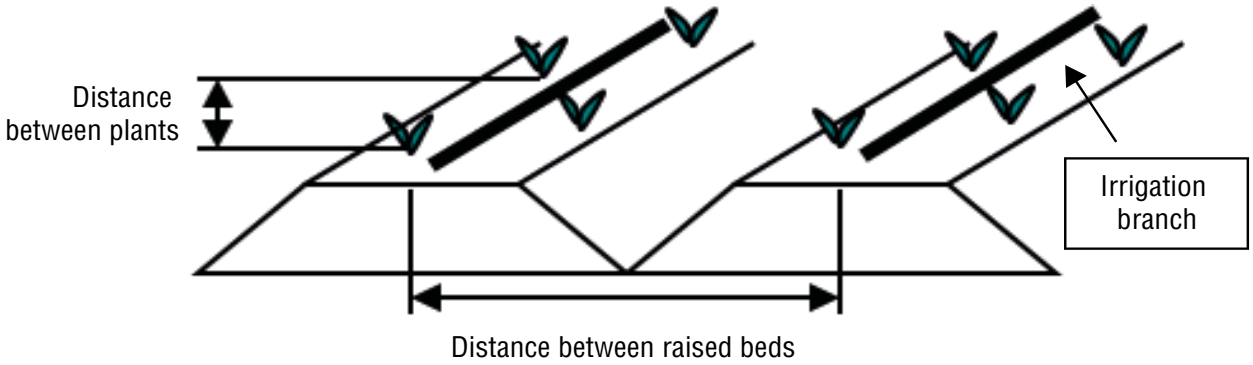
Onions are planted in rows of two or three on ridges. Raised beds, which also adapt well to localized irrigation systems, are normally used for four or more rows. Plant density is 35-40 plants/m^2.

Source: Fundación Cajamar

Trench irrigation



Localised irrigation



Source: Fundación Cajamar

For crops such as lettuces or cabbages, rows can be separated by between 90 cm to 1 m. In the case of artichokes, the separation between rows should be at least 1.5-1.75 cm.

Chard is sown in two lines of plants on raised beds separated 0.5 m and the distance between seeds along the line is 3 cm.

For carrots, the furrows are arranged as for chard, distance of 0.5 m and plants are separated 4 cm in two staggered rows.

Source: Fundación Cajamar

Semiprotected systems

The use of black and white plastics for mulching and cover systems for different crops such as potatoes is possible. It is also possible to use biodegradable plastics, which will eventually completely decompose in the soil.

There are other semi-forced systems, such as micro tunnels and floating covers using transparent plastic or polypropylene, which enable the modification or improvement of temperature and humidity conditions surrounding the plant. They also prevent the entry of certain pests and reduce diseases.

After planting it is especially important to irrigate to ensure plant rooting. The first irrigation is the most important, in order to ensure that the moisture reaches the roots of the plants well.

Source: Fundación Cajamar

Irrigation Installation/Set-up

Once the plot is ready, and the location of each of the crops is known, the irrigation system can be set up.

Drip irrigation is considered to be the most practical and suitable system to efficiently provide for a crop's water requirements.

Different secondary pipes for several crops and water valves for closing irrigation manually

Source: Fundación Cajamar

A water intake with enough pressure, about two atmospheres, is required. The most practical option is a mains water tap, if the surface to be watered is small. In the case of larger area, for example > 500 m^2, another water source should be considered, including the possibility of collecting rainwater and storing it in a tank or pond. In that case, an electric pump would need to be installed.

In order to ensure the supply of water a polyethylene hosepipe with a suitable diameter should be connected to the tap. One or more irrigation programmers can be installed at the entrance to the school garden and can be either battery-powered or connected to mains electricity.

After the programmer, the piping continues with the secondary pipe, using one or more 25 mm diameter polyethylene pipes installed in the plot, pipes known as side or lateral lines are then inserted into these.

The pipe could be 12 mm in diameter, but a 16 mm pipe is recommended. Drippers can be inserted into this pipe or a pipe complete with drippers can be installed. For a school garden installation, the most suitable is to acquire a pipe with drippers every 30 cm.

The secondary pipe is perforated with a 16 mm diameter hole punch and a tape-to-lateral connector is inserted to allow connect with the pipe holder. A valve can also be inserted, which will allow individual crop lines to be opened and closed. The end of the pipes must be closed using a polyethylene ring or plug.

The branches with inserted drippers can be connected in between, with a separation of 1 m or depending on the distance that the different crops are planted. Although as valves are to be fitted, they can subsequently be opened or closed depending on the needs.

Furthermore, tensiometers or moisture probes should be placed at the same time as the irrigation system is installed. It is advisable to locate them it in the crop with the longest life cycle in the plot in order to be used as a guide for general plot management.

Moreover, once the installation is complete, it may be convenient to carry out a series of tests. These will allow you to get to know more about the characteristics of the installation.

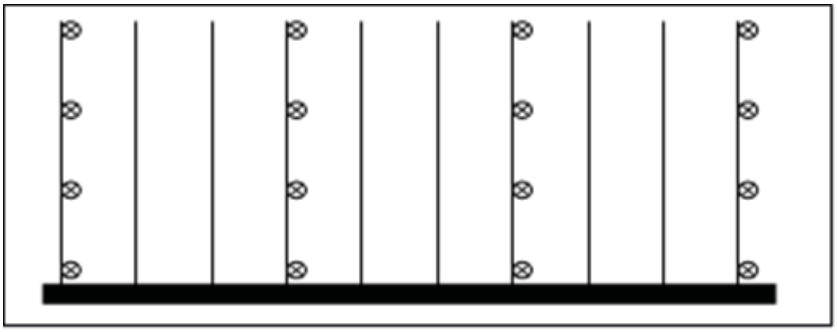
To do this, a few containers are placed under 10-16 drippers distributed throughout the plot and the installation is switched on for five minutes. The water collected during that time is measured and multiplied by 12, thus giving us the flow of each dripper in litres per hour. (12X5's = 60').

The average of the drippers' flows representing the quarter of the lowest flow rate (q25) is calculated. The average flow rates measured in all drippers monitored (qm) is then also calculated.

Watering uniformity can be evaluated with these two results, as follows:

$$WU\ q25/qm \times 100,$$

That uniformity of water application is expressed as a percentage. If > 95 %, is considered excellent. Between 85-95 % good, 80-85 % acceptable, 70-80 % poor and <70 % unacceptable.



Source: Fundación Cajamar

Planting and Sowing

Once the irrigation system has been installed in the plot, planting or sowing can take place.

To establish a vegetable plot, it is important to consider plant spacing, which is the distance between plants and rows.

Potatoes: Tubers are buried to a depth of between 7 to 8 cm. Allow 0.5 and 0.7 m between furrows and 0.3 to 0.4 m between plants.

They can be planted on dates when there is no frost, in areas where the weather is good this can be in January or February. In cold areas, the planting will have to be delayed so avoiding frost. They can also be planted at the beginning of September, considering that in the area where it is grown, after 3 months there will be no frost, that is, it is free of frost until the end of November.

Onions: They are planted in rows of two or three on mounds and with four or more rows on raised beds, which adapt well to localized irrigation systems. Planting density is 35-40 plants/m^2. Densities can be established, with spacings of 60 cm between furrows with two lines and 8 to 11 cm between plants.

Source: Fundación Cajamar

Cauliflowers: Rows are set 1 m apart and the plants are arranged in staggered rows with 0.5 m between plants in the same row. The same layout can be used in a Brussels sprout.

Broccoli: Rows are set 1 m apart and the plants are arranged in staggered lines with 30 cm between plants in the same row.

Lettuces: Rows are set between 90 cm to 1 m apart, with two staggered rows and a spacing of 30 cm between plants in the same row.

Chard: In the case of this plant direct sowing is recommended, with the following spacing: Two rows separated 50cm with 4-5 cm between seeds.

Carrots: As for chard, direct sowing and the same spacing is also recommended.

Source: Fundación Cajamar

7

Crop Care

7.

Crop Care

Weed control, pest and disease control, green infrastructure & biological control methods

Main Pests

Aphids

Aphids are insects that feed by sucking the sap from plants. They appear in large numbers and, since ants feed on the sugary substance (molasses) that they secrete and in return protect them against their enemies, it is common for aphids to associate with ants.

They are small, no more than a few millimetres long, and although their morphology is varied, they are normally rounded or oval. They come in various colours; green, yellow, red, black ... Aphids may or may not be winged and, like most sucking insects, are found on the underside of leaves.

One of the products that can be used in the fight against aphids is a potassium solution.

Agricultural Practices:

- Eliminate weeds and crop debris that could harbour pests.
- Use yellow adhesive chromotropic traps from the beginning of the crop.

- Crops must not be abandoned at the end of their cycle.
- Remove and destroy prunings.
- Ensure to leave a certain period of time between crops.

Biological Control:

- Natural enemies: Adalia bipunctata, Aphelinus abdominales, Aphidius colemani, Aphidius matricariae, Aphidius ervi (for large aphids), Aphidoletes aphidimyza, Chrysoperla carnea, Lysiphlebus testaceipes (Aphis gossyphii and Myzus piberbisofericus persicaeus).
- Banker plants (BP).

Source: Gettyimages

Whitefly

Whitefly is one of the most common pests in agricultural crops and gardens, as it attacks both ornamental plants and vegetables. It appears especially at the hottest times of the year (spring and summer). It is small, measuring between 1 and 3 millimetres. Its presence can be detected by looking at the underside of the leaves.

Regarding biological pest control, as is the case with aphids, it also has its natural enemies such as the insects; Eretmocerus mundus, Nesidiocoris tenuis or the mite Amblyseius swirski, you can also treat it using Beauveria bassiana fungus-based solutions.

Agricultural practices:

- Use yellow adhesive chromotropic traps (sticky traps) from the beginning of the crop.
- Do not abandon the crops at the end of the cycle.
- Leave the plot fallow for some time before planting a new crop.
- Remove weeds and crop waste as they can harbour pests.
- In case of serious infestation, remove the leaves from the lower areas of the plants and destroy them.

Source: Gettyimages

Thrips

Thrips are tiny, winged insects and it is usually necessary to use a magnifying glass to observe them in detail. Thrips belong to the Thysanoptera order, are winged in their adult phase and are so small that their average length is only 1.3 mm. Thrips feed on the contents of the leaves of our crops sucking with their needle-shaped mouth parts. They cause scars to form on the leaves, so deforming them. The damage appears in the form of yellowish, white or silver dots on the leaf surface.

Regarding biological control, it also has insect predators such as Orius laevigatus, Nesidiocoris and mites such as Amblyseius cucumeris, Amblyseius swirski.

Agricultural practices:

- Remove weeds from around the plot, since many harbour this harmful pest which then moves onto the vegetables.
- Use yellow adhesive chromotropic traps (sticky traps), as this colour attracts them, and they get stuck to them. This measure is more effective if it is carried out inside a greenhouse. In the open air, several of these traps can be placed on wooden posts or poles at a height of approximately 50 centimetres.
- Ensure that the state of the plants is ideal, with adequate fertilization, watering and control of other pests, since thrips will cause more damage to stressed plants.
- Use a plastic mulch (ground covering) if possible and opt for a reflective colour such as shiny silver.

Red Spider Mite

Tetranychus urticae. This tiny red mite has two dark side spots and requires a 10 to 20 magnification magnifying glass to be seen. The symptoms: Blemishing and yellowing affecting all plant organs, in more serious infestations webs appears on the leaves themselves. Preferable pest control, early treatment using sulphur dusting or wettable sulphur, or with paraffin oil. It also has natural enemies: Other mites such as Phythoseiulus persimilis, Amblyseius californicus or mosquito-like insects such as Feltiella acarisuga or a small, black ladybird called Stethorus puntillum.

Cotton Leafworm

Spodoptera littoralis caterpillars are brown in colour but not a serious pest. However, Spodoptera exigua, whose caterpillar is green, is. It gnaws the leaves, leaving the epidermis intact at first, it also feeds on the skin of watermelons and the terminal buds of peppers, stunting them, later devouring entire leaves. Helicoverpa (Heliothis) armigera feeds on leaves and enters the fruit. Plusia (Autographa) gamma or "Silver Y moth" feeds mainly on leaves. The tomato moth (Tuta absoluta) penetrates and feeds off the fruit. It also penetrates the leaves, making galleries by feeding off the mesophyll while leaving the epidermis intact, and it also pierces the stems. Biological control using Bacillus thuringiensis or with a baculovirus or spinosad in the first larval stages is authorized.

Red Spider Mite

Source: Fundación Cajamar

Cotton Leafworm

Source: Gettyimages

Leaf Miner

Liriomyza trifolii. The presence of adults causes slight damage to the upper part of the leaves due to whitish spots caused by feeding and laying wounds or laying attempts. The galleries in leaves are caused by the larvae when feeding. Yellow sticky traps can be laced to capture adults. Plants can be treated with paraffin oil,; alternatively, biological control using Diglyphus isaea.

Source: Fundación Cajamar

Pest Control

Tobacco. Aqueous solutions of the alkaloid nicotine are used as an insecticide and miticide. They can be obtained by letting 1.5 kg of tobacco leaf veins stand in 20 L of water for a day. Potassium soap as a wetting agent improves its adherence. It acts, above all, by inhalation, but also by ingestion and contact as it is very volatile and penetrates the insects' integument (skin). Extreme caution must be exercised during application. Commercial formulations based on nicotine sulphate are not authorized in the EU.

Garlic or onion: see the section 'Against diseases'. For use against spider mites, caterpillars and aphids, and as a gastropod repellent.

General insect repellents can be prepared using rue, tansy, wormwood or male mugwort in infusions of 0.5-1 kg of dried plant per 100 L of water, and with macerated eucalyptus 750 g of chopped leaves in 20 L of water.

Sulphur. It can be used preventively as a general repellent, and as a miticide against red and white spider mites and eriophyds. It is phytotoxic at more than 28 ºC. Do not mix with oils or apply after having treated with them. It can be applied as a wettable powder, as a dust and by sublimation. The dusting is carried out when humidity is highest to facilitate its adherence. Take into account that it can harm the beneficial insects.

Soft or potash soap. It acts on contact, softening the membranes of the exoskeleton, alterations in cell physiology occur; it also causes suffocation. It is used against soft-skinned insects and mites. It is also effective for cleaning molasses and eliminating any sooty mould caused. There are products formulated using fatty acids from vegetable oils and potassium salts available on the market. A home-made formula: Prepare 5 kg of sifted ash and 0.5 kg of soap in 10 L of water and heat for 20 minutes; For its application, dissolve 1 L of this solution in 20 L of water.

Iron triphosphate applied to the soil between plants, against snails and slugs.

Jelly. Dissolve 9 g of powdered gelatine for every 1.5 L of warm water and spray on aphids and mites.

Vinegar. Home-made remedy that is often used by farmers as a spray against aphids, dissolving 10 and 20% in water.

Narrow range paraffin oil. Against thrips, leaf miners, aphids, whitefly and mites; acts by asphyxia and disintegration of the chitin of their protective covering. Apply in high doses and at high pressure, stirring the mixture constantly. If a sulphur treatment has been carried out previously, leave thirty days before treating with paraffin oil.

Vegetable oils. Thyme, linseed, soy, peppermint, pine, caraway, neem, basil, etc. oils are used as wetting agents, repellents and as biocides for a wide spectrum of pests.

Biologial strategies:

- Use of banker-plants (Reservoir plants). These provide alternative hosts to aphid parasitoids and enable effective and efficient control of these pests in crops. This is a preventive strategy that enables populations of beneficial insects, such as Aphidius colemani, to survive and breed. Banker plants are crops, such as cereals like wheat or barley, which host populations of aphids specific to these plants, that is, they cannot develop in the crop, such as Ropalosiphum padi. This surrogate organism is a host for parasitoids such as Aphidius colemani. This allows effective preventive control of aphids with low doses of releases of beneficial insects.

- Use of Aromatic Plants:

  - Mint: Improves the taste of Solanaceae, increases the production and quality of cabbages, repels aphids... To be placed between plots.

  - Marigold (Calendula): Repels whiteflies and nematodes. Place it on the borders, surroundings and between the plots.

  - Lemon Balm: Repels certain insects and attracts bees. Not to be planted in the centre but on the sides of the pathway because it is invasive.

  - Parsley: Improves the taste of Solanaceae and asparagus, in addition to protecting them against whiteflies. To be placed between plots.

  - Thyme: Effective repellent against cabbage whitefly. Place it between the beds.

  - Rosemary: Great for attracting pollinators. Place it in the hedges and borders.

- Chamomile: Stimulates crop growth and attracts thrips. Place it in the borders and hedges.
- Salvia: Keeps carrot and cabbage flies under control. Place it in the borders.

Source: Gettyimages

Beneficial for us: Insects and Spiders

- Predatory bedbugs. They feed on aphids and other sucking insects, mites, and small caterpillars. Although they feed on plant sap, they are more beneficial than harmful.
- Flower bugs. "Orius" They feed on large amounts of thrips, about 20 a day and more than 300 throughout their life cycle. They also tend to feed on aphids, butterfly eggs, mites, etc.
- Ladybirds: The best known of all is the ladyird (Coccinella septempunctata, Adalia bipunctata), there are many species of these famous insects, the best known is this indigenous European species, which are sold in some centres specialising

in biological control. Its presence in a garden is a sign that other species, which can be especially inconvenient for our crops, are under control. They are aphids-eaters, consuming 100 aphids a day from their larval stage. It is important to be able to recognise the larvae, the pupae, and the yellowish, elongated egg clusters on the undersides of the leaves.

- Carabidae: Ground beetles, as their name suggests, spend most of their time on the ground, under stones or logs, waiting for the night to feed on large numbers of different larvae, pupae, worms and slugs or snails. Species: Calosoma sp. and Chlaenius sp.

- Fireflies: Also known as "glow worms". Some adults barely eat, but the larvae feed on small snails and other larvae.

- Hoverflies. Syrphids: Flies with a similar colouring to wasps. The adults pollinate flowers, and their larvae are especially important since they consume large numbers of aphids.

- Ants. A disproportionate number of ants can be harmful to a garden, mainly as they can move aphids to new 'pastures', erode the soil so undermining the plants, or remove edible seeds such as sunflower seeds. However, they also help pollinate flowers and keep the numbers of other insects under control.

- Ichneumonid wasp: They attack spiders, but they mostly parasitize insects, especially Lepidoptera (butterflies) and the Braconidae family (aphids).

Ladybirds

Source: Archivo Cajamar

Hoverflies

Source: Gettyimages

- Earwigs: Of this group of insects, it should be highlighted that although earwigs may also do some damage to crops by devouring tender shoots or several petals, they do less harm, than good, and since they are carrion feeders and keep insect populations under control. It is a great predator of many insects, especially aphids. It is active at night and usually retreats to dark, narrow crevices, under stones or upturned pots to rest during the day.

- Lacewings: Belonging to the Neuroptera group, the Lacewing stands out. The greenish, winged adult is often seen but rarely noticed (there are also individuals which are light brown in colour). Their larvae feed on aphids, hence their common name in many Spanish localities: “Aphid wolf”.

- Spiders: Their diversity and predation make them essential garden friends: crab spiders, garden spiders, jumping spiders, wolf spiders, etc. For example, a garden spider devours about 2 kg of insects per year, including many aphids.

Earwigs

Source: Gettyimages

Lacewings

Source: Archivo Cajamar

Spiders

Source: Gettyimages

Main Diseases

Mildew

Solanaceae powdery mildew (Leveillula taurica) and cucurbits (Podosphera fusca). The optimal conditions for it to develop are RH 70 %, 10 ºC < T). At first, a whitish down appears on the top or underside of the leaves, or yellowish spots on the top of the Solanaceae, which evolves into necrotic spots. Preventive measures: Use resistant varieties and remove the basal or lower leaves where the pathogen is present to reduce the amount of inoculum. It must be treated with sulphur right from the onset of the disease. Algae and fungi solutions with enzyme formulations to increase the plant's resistance mechanism, etc. are being tested to combat this disease on an experimental basis. There is however still no conclusive data regarding effectiveness and safety.

Source: Fundación Cajamar

Late Blight (Phytophthora Infestans)

At first, oily spots that later necrotize can be seen on leaves, rhomboid forms appear from the central nerve in the tops of the leaflets, and necrotic spots on the stem or peduncle of the fruit.

Source: Fundación Cajamar

Downy Mildew On Cucurbits (Pseudoperonospora Cubensis)

The oily spots soon become polygonal respecting the veins. They become necrotic on the upper surface and develop a greyish down on the underside. The optimal conditions are RH 90%, and temperatures of between 10 and 25 ºC.

Copper-based products or silica dust are to be used to treat both late blight and downy mildew.

Source: Fundación Cajamar

Grey Mould

Botrytis cinerea needs optimal development conditions of 95% RH, and a temperature of between 17 and 23 ºC. To penetrate the plant, it needs some wound (due to pruning or for other reasons) and the grey mycelium of the fungus appears on sensitive organs; Tomato fruits can develop the so-called "ghost spot", which are small circles with a white outer crown and a dark centre. Once the fungus has appeared, it is necessary to clean the area affected by the rot and then apply a copper paste or carry out a general treatment with copper-based products or silica powder. In any case ventilation to favour the aeration and so lower the relative humidity is recommended.

Bacterium

Erwinia sp. causes watery rot in stems and fruit to give off a bad smell and it survives in soil, water, plant debris, etc. Pseudomonas sp. causes necrotic spots and is transmitted by seeds and plant debris. Clavibacter sp. causes a general "burnt" appearance on the plant, it spreads on seeds, plant debris, etc. They develop when humidity is high and at temperatures of between 20 ºC and 25 ºC. To keep it under control it is recommendable to carry out preventive treatment using copper-based products, increase greenhouse ventilation and deal effectively with previous crop waste.

Grey Mould

Source: Fundación Cajamar

Bacterium

Source: Fundación Cajamar

Virus

The best strategy is to grow resistant plants and to take extreme preventive measures given the uncertainty of a viral infection, and that it is practically impossible to avoid the presence of vector organisms.

Against diseases

- Common Horsetail: It is rich in silica, in a saponin which is toxic for fungi –equisetonine–, in flavonoids and alkaloids (such as nicotine, which also confers it an insecticidal effect). It can be obtained by decoction of 1 kg of fresh, chopped horsetail, or 150 g of powdered horsetail in 10 L of water and mixed with some adherent to improve its effectiveness. Diluted in water at 1: 5 it is recommended for use against mildew, bacteria, blight/rust, etc.

- A formulated extract of citrus pulp and seeds, rich in organic acids (mainly ascorbic), induces the synthesis of phytoalexins, improving the plants' natural defences against bacteria, fungi and algae.

- There are several proposals for using garlic and onions. The allyl polysulfide they contain enable them to be used as antibiotics, fungicides and bactericides. They also act as insecticides and repellents due to alliin, which turns into allicin. An infusion of 700 g of heads or cut bulbs in 10 L of water that can be used undiluted at the rate of 3 treatments at 3-day intervals. Alternatively, a vegetable purine consisting of 10 kg of onions or 1 kg of garlic in 100 L of water, using a 10 % solution for traditional spraying.

- A 50 g infusion of chamomile in 10 L of water protects against fungi in general, and especially melon mildew.

- Sulphur. It is preventive and somewhat curative against powdery mildew. It can be phytotoxic at temperatures above 28 ºC. Do not mix with oils or apply after them. It can be used as a spray as a wettable powder, by dusting and by sublimation. Dusting should be done when the humidity is at its highest to facilitate adherence, take into account that it can be harmful to beneficial insects.

- Copper-based products. These are used in preventive treatment against mildew, Botrytis, bacteria, etc. Formulated based on copper hydroxide, copper oxychloride, tribasic copper sulphate and cuprous oxide; They are applied by spraying, dusting or brushing if it is a paste. Not to be mixed with oils. The accumulation of copper in the soil must be avoided due to its biocidal power and tendency to block other mineral elements (no more than 6 kg of copper per hectare, per year allowed).

- Dairy products. Skimmed milk diluted between 10 and 50 % is used as a disinfectant for hands and pruning and grafting utensils, since its proteins inhibit contact-transmissible viruses (Van der Berkmortel, 1977). A dairy enzyme, lactoperoxidase, can be used against powdery mildew.

Spontaneous Vegetation (Weed) Control

Strictly speaking, weeds are not necessarily a crop's enemies, moreover, if they are well-managed, they can be useful allies. Since they are a CO_2 sink, retaining carbon in their structure by photosynthesis, they anticipate the presence of natural enemies which are beneficial against pests and, if left on the ground after weeding, contribute humus to the soil when they decompose. When their presence is not desired, it is best to take preventive action, for example, avoiding poorly composted manure which can contain seeds.

Mulching (covering the soil) with uncontaminated plant waste, such as straw, coconut fibre or jute, etc., or with plastic polyethylene sheeting, even though it makes it more difficult for the soil to breathe, or with sand, cardboard or agro-textiles such as polypropylene mesh, etc., are also a possibility in the fight against weeds. However, these cannot be improvised and will need to be planned.

Tasks such as mowing, scything, strimming and hoeing are recommended.

Thermal treatments can also be carried out using solarization during the summer, butane or propane blow torches can also be used.

Another technique used in soil management is the so-called false sowing. The soil is prepared as if it were going to be sown, but is not, to encourage the appearance of the first weeds, which are later destroyed so as not to affect the first stages of the crop; This technique can lead to a variation in the usual sowing date.

8

Water Supply & Water Requirement Calculation

8.

Water Supply & Water Requirement Calculation

Water is a scarce commodity in general, particularly for use in agriculture and, especially in arid areas, is becoming a critical problem. Improvement in agricultural water-use efficiency is necessary to guarantee responsible use.

Only 2.5 % of the water stored on Earth is fresh water. About 69 % of the planet's fresh water is used for agriculture, 16 % goes to industry and 12 % for domestic use. The use of water is becoming a cause for dispute between countries, and also between regions within the same country.

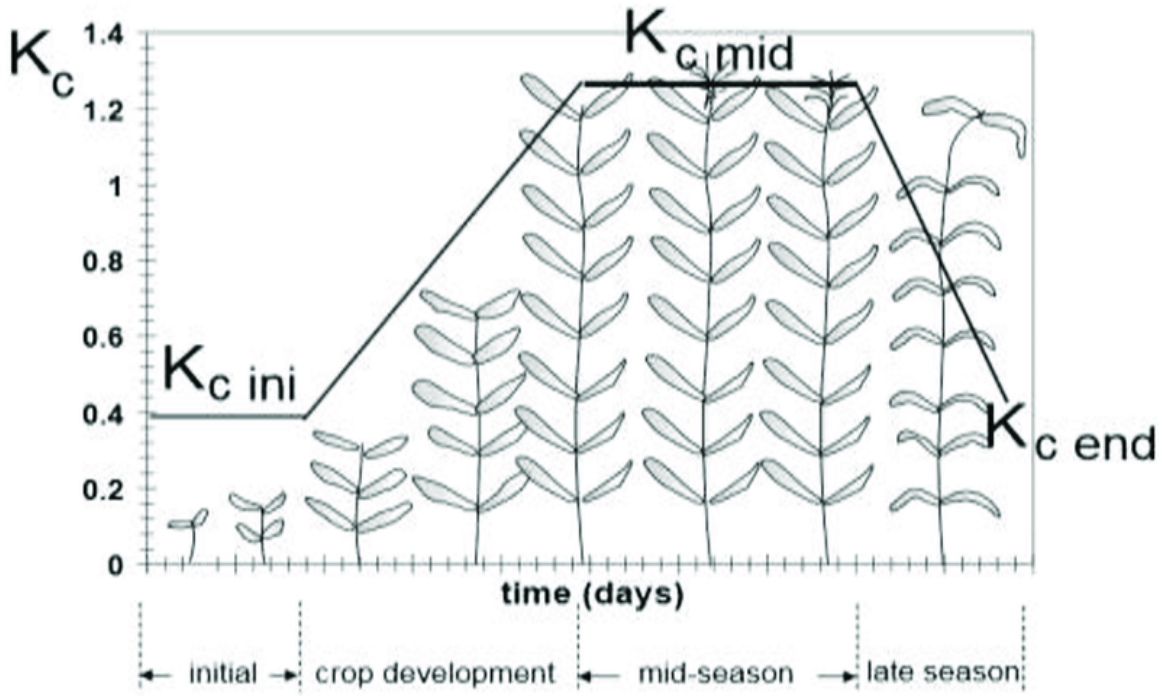
40 % of agriculture worldwide is irrigated. Water scarcity can be attributed to different causes: periods of drought, desertification, and man-made water shortages. The world's population is still growing, and it is estimated that by 2050 an increase in food production of between 70 to 90 % will be required. For that reason it is necessary to find ways to improve agricultural water-use efficiency.

Another reason that will lead to an increase in water use is climate change as a consequence of the increasing in temperatures on the planet and the reduction in rainfall. Climate change has a negative effect on water resources. Mediterranean regions are especially affected, as they are already considered arid or semi-arid areas.

Crop Water Requirements

Water requirement is defined as the amount of water needed to compensate for "crop evapotranspiration". For this reason, water requirement depends on climate conditions, in which effective rainfall, together with irrigation, compensate for said evapotranspiration.

Evapotranspiration (ET) is the combination of two separate processes: evaporation and transpiration. Evaporation is a process in which liquid water is transformed into water vapor and transpiration consists of the vaporization of liquid water stored in plant tissues, mainly through the stomata. The main factors affecting evapotranspiration are climate-based (solar radiation, temperature, wind speed, relative humidity). The evaporation of a given surface area of lawn (ETo) is taken as a reference.



Source: FAO

For this reason, to calculate the water requirements for each of the crops, it is necessary to determine crop evapotranspiration (ETc) = ETo X Kc. Kc is a coefficient that depends on the crop and which varies according what stage it is at: during the initial stage the values are low, they increase during the development stage, usually reaching a maximum in the intermediate stage or while the fruit are growing and decrease during harvesting, as shown in the figure.

To fine-tune the ETc calculation, a series of corrections based on local conditions must be taken into account, such as irrigation uniformity, water salinity, and crop resistance to salinity, so ETc can be multiplied by a correction factor of 0.9 or 0.7.

To calculate the irrigation requirements (IR), crop evapotranspiration must be subtracted from the effective precipitation (EP)

Calculation IR = ETc- EP

An irrigation programmer is used in drip irrigation systems. It is programmed to control irrigation time (It) and days of the week.

It=IR (mm)/Flow (mm/hour) from which the irrigation hours are determined, which will have to be transformed into minutes, or hours and minutes.

To calculate the flow, the number of drippers or emitters/m^2 and the real flow of each dripper must be known. Irrigation flow = n.º drippers/m^2 X flow of each dripper in litres/m^2 per hour = litres/m^2 and hour.

Source: Gettyimages

Irrigation Scheduling and Soil Moisture Monitoring

Scheduling irrigation consists of determining the amount of water to apply and the time of application. When irrigation programmers are used, especially in drip irrigation systems, this translates into irrigation time and the time that must elapse between each irrigation, as explained in the previous section. This programming depends on the needs of the crop and the water storage capacity of the soil, which, at the same time, also depends on of the type of soil texture. Sandy soils have a low water storage capacity and, on the contrary, clay ones have a high storage capacity, that is why sandy soils are always irrigated more frequently than clayey ones.

With irrigation, the objective is to maintain moisture levels in the soil surrounding of the plant's roots to make water available for them. To ensure this, there are instruments to measure the level of soil moisture at different depths, the most important of all being where the largest volume of roots is located. In horticultural crops this depth is usually between 20 and 40 cm. These sensors help to improve irrigation scheduling, ensuring an adequate level of soil moisture, avoiding water losses through drainage at a greater depth.

To achieve this, it is important to install the soil sensors correctly, choosing the proper depth of the roots and near the irrigation system dripper. If you have a second soil moisture probe, it can be installed deeper, at 50 cm for example, to detect possible drainage and thus establish the appropriate irrigation time to avoid water loss.

Source: Gettyimages

9

Health & Nutrition

9.

Health & Nutrition

The agri-food innovation team here at the Cajamar Cooperative Group research centres is well aware that the basic fundamental rights of any person should undoubtedly be; to have a decent diet and be in good health and, in the case of children and teenagers, this principle should be as fundamental and unquestionable as life itself. A person's health is conditioned by their intake of food, constituting the basis of life itself. We develop according to the food we eat and for this reason humanity has evolved based on the food available through time leading to the adage: "We are what we eat".

Although we hold of the title of ambassadors of health thanks to our Mediterranean Diet, to merit this fundamental right the nutritional value of food must be redefined beyond its being safe and tasty. It must be accessible and healthy, that is, we must introduce considerations regarding the long-term effects on health. Current agronomic management needs to be efficient because the scientific and specialist community is clear that our health really begins with the health that we are able to give our soils. The more the population grows, the more the planet's resources diminish. Therefore, more than ever before, we must take advantage of the valuable by-products that have historically been called waste. The day will come when this concept becomes part of history. We must not forget to be rigorous in the dissemination and transfer of information by all specialists and professionals in the hospitality sector, dieticians and nutritionists, researchers, chefs and innovative entrepreneurs who strive to maintain this fundamental cause alive, on a daily basis, in the face of so much false information.

It is essential not only to transmit knowledge in a way for children to understand it, and they must also be trained in a series of healthy eating habits, taught in the same way as with other subjects such as mathematics or languages. It is true that the knowledge will be adapted to their local culture and influenced by their own tastes and those of their families. Through social experiences such as meals with family or friends, in school canteens, at celebrations, etc. everybody shows their preferences, and a child will not learn to eat well without having come into direct contact with a wide variety of products. In the same way that behaviour or guidelines regarding personal hygiene or manners and respect are transmitted to children, it is essential to educate them regarding the healthiest possible food and nutrition. This task must be carried out initially by parents who may find themselves faced with different scenarios, such as a child with good appetite who loves to try everything, or others which are quite the opposite. The simplest thing is often to give the child the few things they like, leading them into bad eating habits or giving in and bribing them which only makes the next meal scenarios progressively more difficult.

Nutrition education requires patience, dedication by parents, not making unacceptable concessions and a certain respect for the child's appetite, provided that the child's growth and development is within normal limits, in the opinion of the paediatrician. Parents who fuss excessively over food can create an unhealthy dependency in their children on an event that should be normal and pleasant. Children's appetites, like those of adults, can vary related to different stages of their development. There are times when growth slows down, or stops, and nutritional requirements are lower. On the contrary, there are stages in which pupils eat with pleasure and in abundance in response to their bodies' demand for the nutrients they need to grow. This situation must be understood by the family. Weight and height are excellent indicators of adequate nutritional status, and the opinion of the paediatrician is essential to assess whether the situation can be classified as normal or as a cause for concern.

We must be more enthusiastic than ever, even in the current scenario, in telling children that fruit and vegetables are considered to be the fundamental pillar of a healthy diet and have been one of the basic parts of mankind's nutrition since the dawn of humanity. Due to market globalization, seasonality has become a thing of the past and we can find the same produce on the greengrocer's shelves the year round. In short, we are talking about a wide variety of produce that is not limited to seasons, their organoleptic attributes make them ideal for adding richness and colour to gastronomy which is, in

turn, becoming increasingly demanding and refined. They can be eaten throughout the day, for breakfast, lunch, tea, dinner and even between meals, desiccated vegetables have recently become very fashionable, the ideal healthy snack, even replacing potato crisps. Another advantage is the many ways they can be prepared, from simply boiling, grilling or stewing to the preparation of juices and purees and in salads and fruit salads.

All you need to know to nourish yourself well

Parents often ask themselves what the ideal diet for their children should be. If that is not clear for us adults, imagine our children. Bearing this in mind here are some basic recommendations for food that children should consume on a daily basis, and above all why it is necessary, for their nutrition to be both balanced and healthy. The idea of this chapter is to provide you with enough knowledge to design wholesome dishes which also nourish you in the healthiest possible way:

Essential components of a youngster's diet:

- Proteins
- Carbohydrates
- Lipids
- Vitamins
- Minerals

Proteins

Protein needs are highest at birth, then they decrease only to increase again when young people enter puberty. Proteins come mainly from two sources, those of animal origin and those of vegetable origin. Animal proteins are usually of higher quality, that means that the number of essential amino acids it contains is greater, as is the quantity.

Carbohydrates

An essential part of any diet to meet our energy needs, so it is necessary to encourage the consumption of foods containing them. There are two types of carbohydrates: complex,

such as those found in cereals; and simple, such as sugar. A healthy diet must have adequate amounts of both, but with a predominance of the complex type.

The daily consumption of simple carbohydrates, such as pastries, leads to problems of obesity and even diabetes in the future if consumed in excess. It is important to consume only what is needed.

Foods rich in Proteins	
Of animal origin	**Of plant origin[a]**
Fresh meats: Add your consumption	Pulse* (Legumes)
Processed meats (Delicatessen)	Nuts
Milk and dairy products	Cereals such as wheat, rice, corn. Quinoa is an interesting new food.
Eggs	Legumes* such as peas, green beans, broad beans
Fatty (blue) and lean (white) fish	Potatoes, carrot, pepper, tomato, zucchini
Seafood	Seafood
Insects for human consumption	Insects for human consumption

[a] *The quality of vegetable proteins can be enriched by eating pulse, rice, and vegetables together.*

* *A pulse is the edible seed from a legume plant. Pulses include beans, lentils, and peas. A legume refers to any plant from the Fabaceae family that would include its leaves, stems, and pods.*

Foods rich in Carbohydrates	
Complex	**Simple**
Rice	Sugar
Bread	Jam
Pasta	Honey
Potatoes	Fruit
Legumes	Sweets
Vegetables	

Lipids

It should not be forgotten that countries in the Western world consume higher levels of fat than recommended. The reduction in the content of this nutrient, especially animal fats (saturated), in diets, is highly recommended. However, the consumption of vegetable fats (monounsaturated) is recommended, especially olive oil and avocados.

Foods rich in Lipids	
Fatty foods of animal origin	Foods high in fats of vegetable origin
Butter	Olives, Olive oil
Bacon	Avocado
Lard	Nuts such as peanuts and almonds

It should never be forgotten that: "The abuse of fried foods contributes to obesity"

Vitamins

These nutrients are essential for life. They can be obtained through a varied diet rich in fruit and vegetables, remember the slogan "5 a day". They should be ingested naturally in food, and supplements should only be resorted to when advised by a doctor.

Foods rich in Vitamins		
A y C	B	Folato y/o ácido fólico
Fruit and vegetables such as carrots, peppers of any colour, tomatoes, citrus fruit, strawberries, kiwis, apricots, peaches…	Meat and fish, eggs and dairy products	Fruit and vegetables in general

Minerals

In addition to being essential for our entire body to function properly, they are the key to the formation and synthesis of molecules, tissues, etc.

Calcium (Ca)	
Helps	**Foods rich in calcium**
Maintain bones	Milk and dairy products (cheese)
Blood clotting	Fish
Normal metabolism	Fruit and vegetables
Neurotransmission	Nuts

Remember: "Our bodies not as good at absorbing the calcium contained in foods of vegetable origin"

Iron (Fe)	
Helps	**Iron rich foods:**
Immune System	Liver, kidneys, beef in general
Cognitive Functions	Eggs
Red Blood Corpuscle Formation	Molluscs (mussels)
Blood Clotting	Legumes, nuts, breakfast cereals

Phosporous (P)	
Helps	**Foods rich in Phosporous**
Membranes function correctly	Pulse
Blood clotting	Egg
Maintain bones and teeth	Nuts
Blood clotting	Cheese
	Carrots, broccoli
	Fish

Magnesium (Mg)	
Helps	**Foods rich in Magnesium**
Reduce tiredness and fatigue	Pulse
The nervous system	Nuts
The protein system	Avocados
Bones, teeth	Leafy vegetables
	Chocolate, bananas

Potassium (K)	
Helps	**Foods rich in Potassium**
The immune system	Pulse
The nervous system	Leafy vegetables and fruit
Muscles funcion correctly	Fruits
Bones, teeth	Mushrooms
	Potatoes, garlic

Iodine, salted fish and iodized salt are noteworthy. Dental caries is a major public health problem. The favorable action of fluoride has been proven to protect against aggressive organic acids produced by carcinogenic germs in dental plaque.

Educational Project for Schoolchildren

Exercise

Have a look at the food you have at home and, based on what you have learned in the previous chapter, put them into groups. They are interesting because they are essential elements for your development, and they protect your health.

Here is an example.

If we are doing calcium, write or draw a large Ca (the element's symbol) on a page, if you don't know an element's symbol, you can look it up in the periodic table. Arrange the food around it and take a photo. To help you, have a look at the previous list or do an online search.

Source: Gettyimages

Conclusion: If there are a lot of the foods that you eat every day in the photo, it means that you have a good supply of that essential element. If, on the other hand, you see only a few or very few, be careful because you need to eat more foods that contain enough of that essential element.

This exercise can also help you when you go shopping with your parents. You could suggest them what food you would like to eat to have a better-balanced diet and healthier lifestyle habits.

Healthy eating: passing on the knowledge

In the same way maths, philosophy, history and so on are taught at school, so the teaching of nutrition and health should also be compulsory. This is because a better quality of life, and the probability of getting fewer diseases, depend on the good eating habits we acquire. The following objectives are a proposal to get to know and try to achieve. Here is an activity that you can do with your family or school friends.

The food pyramid: Getting to know and learning how to interpret a food pyramid is essential. It teaches us which foods need to be included in a diet and how regularly they must be consumed. The foods that you see at the base of the pyramid should be eaten every day. Going upwards, the foods in the middle of the pyramid should be eaten several times a week. The foods found at the top of the pyramid should only be eaten very rarely.

As part of the information transfer program carried out in schools nationwide by Cajamar, we are aware of how important it is for children to be able to interpret the information in a food pyramid. We have seen that the best way to achieve this is to get them to take part and for them to play games involving it. Once the pyramid is explained to them, and how food is classified, they are presented with a great variety of foods and are asked to classify them in the pyramid.

Food pyramid activity. Download a food pyramid from the internet, draw a table with three columns and write the headings: breakfast, lunch and dinner on it. While you are having breakfast, lunch, or dinner, look at the food you are eating and make a note of it under the headings, breakfast, lunch and dinner. During each meal, depending on what you are eating, finish by looking at which part of the pyramid it is in.

In the conclusions, look and see if what you have for your breakfast, lunch and dinner is near the base. If you see that there are any at the top of the pyramid, let your parents know you would like to eat healthier, more wholesome food.

Source: Gettyimages

Promotion of fruit and vegetable produce consumption amongst the world's child population

By international organizations and in the educational centres themselves. Consuming a variety of fruit and vegetables guarantees sufficient intake of most minerals, in addition, it can help displace foods which are rich in saturated fat, sugar or salt. The report of a consultative meeting of experts recently organized by WHO and FAO on diet, nutrition and the prevention of chronic diseases, recommended the consumption of a minimum of 400 g of fruit and vegetables per day to prevent chronic diseases such as heart disease, cancer, diabetes, or obesity and even delay the onset of disorders caused by aging. This is because life expectancy is increasing, and new disorders, that were not even contemplated previously, are beginning to appear. The report states that there is compelling evidence that fruit and vegetables reduce the risk of obesity and cardiovascular disease and that they are likely to reduce the risk of diabetes as well.

Basic food intake rules by meal and age range

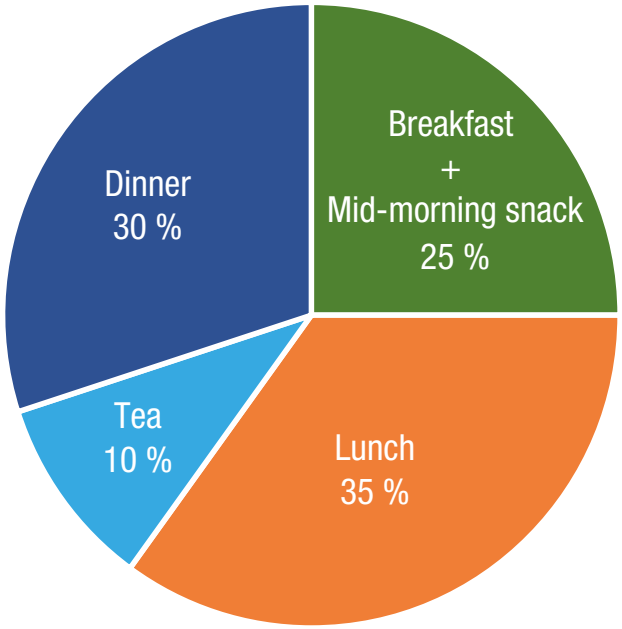
The essential stage in the formation of eating habits is when children are young, that is to say, up to age of six (6). A child must learn to eat everything, fruit and vegetables of all colours because each of them provides certain health benefits due to the bioactive substances they contain. The energy needs for a child's normal growth and development must be covered very well. Physical activity as a preventive and healthy measure, along with diet, must be instilled. Good quality proteins should be eaten because they need more input (meat, fish, legumes, eggs, dairy). The abuse of sweets must be avoided. Above all this is the period when a child must get used to well-defined timetables and learn to enjoy eating.

Up to 12 years of age, growth needs are still a priority, but weight and the pace of development must always be monitored. They are establishing their preferences and it is a fundamental stage during which children only want to eat whatever they like. For normal growth and development, the following should be consumed: dairy products, fruit, vegetables, salad and bread, alternating with a variety of meats as well as white and blue fish. Pulse, rice, pasta, and eggs should be included during weekdays. And as always, moderate consumption of buns, sweets and soft drinks.

Full development takes place up to the age of 16, prior to adolescence, and for this reason it is essential to meet energy requirements, good quality protein consumption and adequate intake of minerals such as calcium, for example.

Children must learn not to over- or undereat, no matter how much they like, or dislike, the food. They must eat the right amount and at the right time, whether it is at home or in school canteens the habit must be established. Overweight is one of the main problems of today's children, especially in industrialized countries. They should be encouraged to do some type of sporting activity from home.

Meal Allocation for Young People



Instil the Mediterranean Diet in schoolchildren from a very young age

The Mediterranean Diet "The Origin"

The Mediterranean Sea (Cradle Of Civilizations)

GREEKS

ROMANS

EGIPTIANS

PHOENICIANS

MUSLIMS

THE BRONZE AGE: OLIVES

THE BIBLE: 200 REFERENCES TO OLIVE OIL

Throughout its history the mediterranean diet has known how not to include foods that were less healthy for its people, and to incorporate wholesome, organoleptic elements from abroad so enriching its properties. "The mediterranean diet is synonymous with health and renowned the world over. It is probably the best ambassador of the mediterranean peoples"

The Mediterranean Diet "Nutritional Qualities"

FRUITS AND VEGETABLES
Very low-fat foods, a good source of complex carbohydrates (slow to digest, good for insulin), cholesterol free, a source of fibre, minerals.
It is an important source of vitamins, minerals, flavonoids and polyphenols. In addition to glucosinolates, certain alkaloids, etc.

PULSE
These seeds are rich in energy, nutrients and bioactive substances. Rich in phytosterols (they reduce the absorption of cholesterol), complex Carbohydrates, fibre, unsaturated fats, proteins, amino acids, etc.

The Mediterranean Diet "Nutritional Qualities"

DRIED FRUIT & NUTS
They are high in unsaturated fats and are therefore also high in calories, but they are good for you, something similar to vegetable omega-3, fibre, minerals, vitamin E, phytosterols and polyphenols.

OLIVE OIL
As it is olive juice, it contains oleic acid, phytosterols, vitamin E and antioxidants, and the wholesome properties of hydroxytyrosol and its derivatives have been admitted by the EFSA.
It favours the absorption of bioactive substances in our body.

The Mediterranean Diet "Nutritional Qualities"

Aromatic herbs and spices; those great allies. Wholesome, with a touch of class

Nowadays, aromatic herbs and spices are no longer magical and belong to an important group of plants characterised by their bioactive substances such as antioxidants, essences, glycosides, resins, tannins, minerals, etc. which have many, varied uses and, especially, certain scientifically proven therapeutical applications.

Teaching children how to change to healthy eating habits

Parents and school canteens alike, lack the time to cook or prepare food and for that reason today's society more frequently opts for easily consumed, industrialized products (fast food) with a higher energy content and lower amounts of such important substances as vitamins, fibre and antioxidants. For this reason, it is important to encourage and promote the consumption of fresh fruit and vegetables to meet the daily intake needs of the type of substances which are so important for health. Children must be taught to value the importance of consuming them:

- To encourage their consumption, it is important to introduce a great variety of fruit for desserts and vegetables for garnishing meals, replacing fried food, especially potatoes, etc.
- It is essential to organize schedules and the amount of food that is eaten, which must be distributed as follows, breakfast (25 %), lunch (35 %), snack (10 %) and dinner (30 %).
- Avoid snacking, abuse of pastries and very sugary foods.
- Family supervision, but without putting pressure on the child. They should not feel that eating is torture but that it is a pleasure to be with the family and enjoy mealtimes together.
- It must not be forgotten that obesity is a major problem and must be avoided. Consult a specialist as soon as it occurs.
- Water is always the best drink.
- Fruit and salads must be regular and abundant.
- Keep excess fat, sugar, and salt under control.
- It is essential for children to be trained in healthy eating habits by families, schools and even the media.

Healthy eating pyramid

Fats, oils & sweets

Meat, fish ...

Milk, cheese & dairy

Fruit & vegetables

Bread, cereals & rice

Better to drink water than sugary drinks

10

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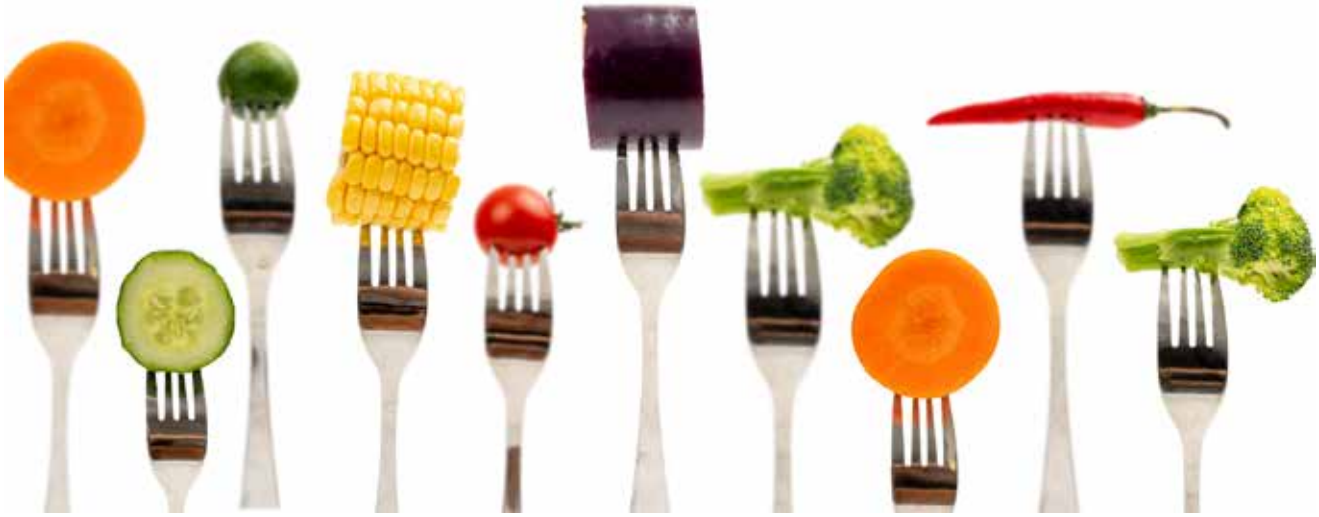

Co-funded by the Erasmus+ Programme of the European Union

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The project «eSGarden: School Gardens for Future Citizens ERASMUS+/2018-1-ES01-KA201-050599» has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for an use which may be made of the information contained therein.

GRUPO COOPERATIVO CAJAMAR