University of Szeged
Plant Science and Environmental Protection Institute
Hódmezővásárhely, Hungary

HORTICULTURE

written by

Ferenc Lantos PhD

SZTE MGK
HÓDMEZŐVÁSÁRHELY

HORTICULTURE

for BSc. students

written by

Ferenc Lantos PhD

UNIVERSITY OF SZEGED

reviewed by

Prof. Dr. Lajos Helyes

Prof. Dr. Lajos Tanács

Márta Bodor Kopunovicsné

ISBN 978-963-688-030-9

CONTENTS

FOREWORD

In Hungary, the cultivation of vegetables and fruits is a nearly 400year-old tradition. This includes cultivation and breeding as well. Over the years, it has grown into an applied science within horticulture and has deservedly become world-famous. Historical eras have always developed and modernized Hungarian horticulture. The first Hungarian-language scientific attributed to János Lippai was published in 1664. It was the book titled “Pozsonyi kert” (Pozsony Garden) . In this work, we can already get an idea about young plant cultivation, the use of organic manure and certain cultivated plants. But the book does not yet include the Latin names of the vegetables and fruits. For example, "Turkish pepper" corresponds to today's sweet pepper (*Capsicum annuum* L.).

At that time, gardening equipment was significantly more advanced in Western Europe. In the 17th century, early seedlings were grown in France under a glass bell jar, which protected the tiny plants from low temperatures, and the hole in the top protected them from possible excessive heat. The Hungarian vegetable cultivation was revolutionized by Bulgarian migrants, from Turkish reign in Hungary, and between the 18th to 19th centuries the Hungarian vegetable gardening was ranked among the first in Europe. The fruit production became an independent Hungarian horticulture. A number of fruit species were bred by Hungarians. Several research institutes were established in Hungary. Subsequently, national agricultural certification institutes were established to control quality. The work of many Hungarian horticultural engineers has raised the vegetable production to European levels. Albert Szent-Györgyi in his experiments with paprika, was able to isolate vitamin C, i.e. ascorbic acid. From the 20th century, the intensive hybrid plant production represented a new trend in the horticulture. In this growing the Holland and Israeli technology became world-famous. This is what we are trying to master. In modern horticultural production the environmental factors (air humidity, light, nutrient, water, CO_2, O_2) are ensured by specialized equipment.

In our work, we introduce the necessary factors of vegetable and fruit production. We will present in detail the work phases, tools and equipment of modern horticulture. We will systematize the biological characteristics of plants and their cultivation requirements. Subsequently we analyse pathogens and pests that occur during cultivation. In our note, we would like to place greater emphasis on environmentally friendly forms of farming, therefore - in the plant protection chapter – we describe the ecological and biological plant protection options. You can read about the biological effects of vegetables and fruits to human body in a special chapter of our note.

Hungarian horticulture is our heritage, which we must continue!

Ferenc Lantos

Chapter 1

Botanical classification of vegetables

Vegetables can be annual, biennial or perennial plants. All fruits belong to the perennial plant group. Vegetables are grown low or high air space plastic tunnel or greenhouse. The fruits are grown exclusively in open fields, except for strawberries. In order to select the optimal cultivation, the crop rotation and growing equipment, we need to know the botanical characters of the plants. We need to know the plant family to which the plant belongs. Vegetables grown in greenhouse and cultivated on field in Hungary, can be classified into the following groups with binominal name:

Table 1. Botanical classification

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Solanales
Family:	Solanaceae
Genus:	Capsicum
Species:	*Capsicum annuum*

Nightshade family

- **sweet pepper** (*Capsicum annuum* L.)
- **powdery pepper** (*Capsicum annuum conv. Grossum* L.)
- **tomato** (*Lycopersicon esculentum* Mill.)
- **early potato** (*Solanum tuberosum* L.)

Squash and melon family

- **cucumber** (*Cucumis sativus* L.)
- **water melon** (*Citrillus lanatus* L.)
- **sugar melon** (*Cucumis melo* L.)

Onion amily

- **onion** (*Allium cepa* L.)
- **garlic** (*Allium sativum* L.)

Brassicas family

- **cabbage** (*Brassica oleracea* L.)
- **cauliflower** (*Brassica oleracea convar. botrytis* Duch.)
- **radish** (*Raphanus sativus* L.)

Sunflower family

- **lettuce** (*Lactuca sativa* L.)

Carrot family

- **carrot** (*Daucus carota* L. *subsp. sativus*)
- **parsley** (*Petroselium crispum* L.)
- **celery** (*Apium graveolens* L.)

Legumes family

- **bean** (*Phaseolus vulgaris* L.)

Grasses family

- **sweet corn** (*Zea mays convar. saccharata* Koern.)
- **popcorn** (*Zea mays everta*)

Mushroom family

- **mushroom** (*Agaricus bisporus*)

*

- **Annual vegetables**:

those plants that reach economic, biological maturity and seed production in the same year during a given growing season. e.g.: sweet pepper (*Capsicum annuum* L.), tomato (*Lycopersicon esculentum* Mill.), cucumber (*Cucumis sativus* L.).

- **Biennial vegetables**:

those plants whose economic value develops in a given year, but which do not develop seed stalks, fruits and seeds grow the following year. In case of their seed production, the selected plants should be placed in a warm place during the winter time. e.g.: cabbage family (*Brassica spp*.), carrot family (*Daucus carota*).

- **Perennial vegetables**:

those plants whose overwintering organs are deep underground. When grown in the same area, they develop flowers and fruits for several years. e.g.: onion family (Alliaceae), horseradish (*Armoracia rusticana* Gaertn.), asparagus (*Asparagus officinalis* L.).

Vegetables play an important role in human nutrition. They contain very little fat and calories but they are very rich in vitamins, minerals and carbohydrates (in form of fructose and glucose) and a number of bioactive antioxidant substances. Ergo, they supply dietary fibre and they are important sources of essential vitamins, minerals, and trace elements. On effect of vegetable consumption, there is a reduction in the incidence of cancer, stroke, cardiovascular disease, and other chronic ailments. From this aspect the quality of the vegetables is a very important factor in horticultural production.

Chapter 2

Crop rotation

Gardeners have long recognized that suitable rotations such as planting spring vegetables for human consumption make it possible to restore or to maintain productive soils. Ancient Near-Eastern farmers practiced crop rotation in 6000 BC, alternately planting legumes and brassicas and onion. Over time, crop rotation has modernized. We differentiate between several crop rotation systems:

- **Two-field systems**

Under a two-field rotation, half the land was planted in a year, while the other half was left fallow. Then the following year, the two fields were reversed. In ancient China both the two- and three-field systems had been used.

- **Three-field systems**

According Lienhard (2023) from the 9th century to the 11th century, farmers in Europe transitioned from a two-field system to a three-field system. This system persisted until the 20th century. Available land was divided into three sections. One section was planted in the autumn with rye or winter wheat, followed by spring oats or barley, while the second section grew crops such as one of the legumes, namely peas, lentils, or beans; and the third field was left fallow. The three fields were rotated so that every three years, one of the fields would rest and was fallow. Under the two-field system, only half the land was planted in any year. Under the new three-field rotation system, two thirds of the land was planted, potentially yielding a larger harvest. But the additional crops had a more significant effect than mere quantitative productivity. Since the spring crops were mostly legumes, which fix nitrogen necessary for plants to make proteins, they increased the overall nutrition need of people.

- **Four-field rotations**

Gardeners in the region of Waasland (in present-day northern Belgium) pioneered a four-field rotation in the early 16th century, and the British agriculturist Charles Townshend (1674–1738) popularised this system in the 18th century. The sequence of four crops (wheat, turnips, barley and clover), included a fodder crop and a grazing crop, allowed livestock to be bred year-round. The four-field crop rotation became a key development in the British Agricultural Revolution.

Many crops, for instance vegetables, are critical for the market. While often the most profitable for farmers, these crops exhaust the soil. Vegetables typically have low biomass and shallow roots: it means the plant contributes low residue to the surrounding soil and has limited effect on its structure. With much of the soil around the plant is exposed to disruption by rainfall and traffic, fields with vegetables experience faster break down of organic matter by microbes, leaving fewer nutrients for future plants. We must ensure the optimal organic manure in the soil during the cultivation. The principle of crop rotation is to grow specific groups of vegetables on a different part of the vegetable plot each year. This helps reduce a build-up of crop-specific pest and disease problems and it organises groups of crops according to their cultivation needs.

Summary:

improving soil structure

it can inhibit the overgrowth of pests,

it can inhibit the overgrowth of weed,

better quality and yield

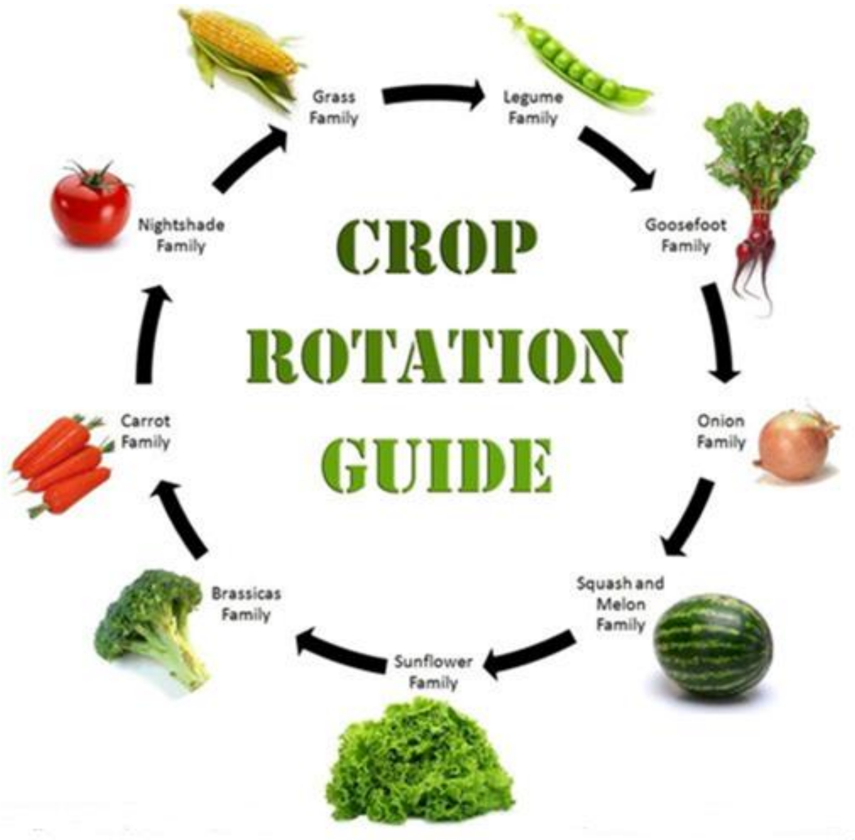


Figure 1. Horticultural crop rotation

Chapter 3

Cultivation equipment

The cultivation of vegetables can be in open-field or in growing equipment of various sizes. Open-field cultivation was already known in ancient Egypt and China. Perhaps as old as civilized man. The using of organic manure, crop rotation, soil rotation and irrigation characterize this cultivation. Nowadays, all this is done with modern machines.

Modern, intensive vegetable cultivation takes place in artificially constructed growing equipment. Their sizes and shapes are different. The heating, lighting, ventilation technology and nutrient supply are all artificially controlled mechanisms.

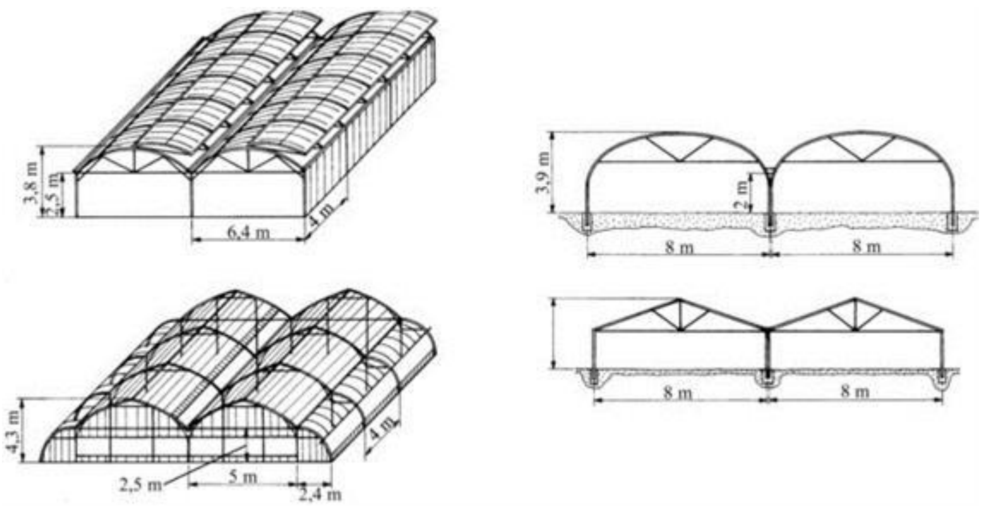


Figure 2. Different forms of cultivation equipment

The *low air space plastic tunnel* is practical for lettuce, potato, carrot, parsley and cabbage growing.

The *high air space plastic tunnel and greenhouse* is practical for sweet pepper, tomato, cucumber, water melon, sweet melon and strawberry growing.

- **Soilless growing technology**

During the intensive vegetable growing we don't use soil. The plants are grown in rock wool or coconut fibre cubes, in generally. We can talk about a special plant growing method, is the so-called "hydroponics". In this technology the root mass of the plants is in a liquid artificial fertilizer plant solution.

The material of rock wool and coconut fibre don't content nutrients, these we must ensure for plants during the total cultivation. For this a specific nutrient recipe is applicated.

Table 2. Nutrient-supply of sweet pepper

Nutrient (mg/l)	**Start**	**1st month**	**Fruit ripening**	**Standard**
N	200	250	250	250
P	50	55	50	50
K	160	200-250	250-300	200-250
Ca	220	250	250	220-250
Mg	50	50	50	40
S	30	40	40	30
Fe	2	2	2	2
Mn	0.2	0.2	0.2	0.2
B	0.4	0.5	0.5	0.5
Cu	0.1	0.05	0.05	0.05
Zn	0.2	0.2	0.2	0.2
Mo	0.1	0.1	0.1	0.1
EC (mS/cm)	2-2.5	2-2.5	2-2.5	2-2.5
pH	5-6	5-6	5-7	6-7

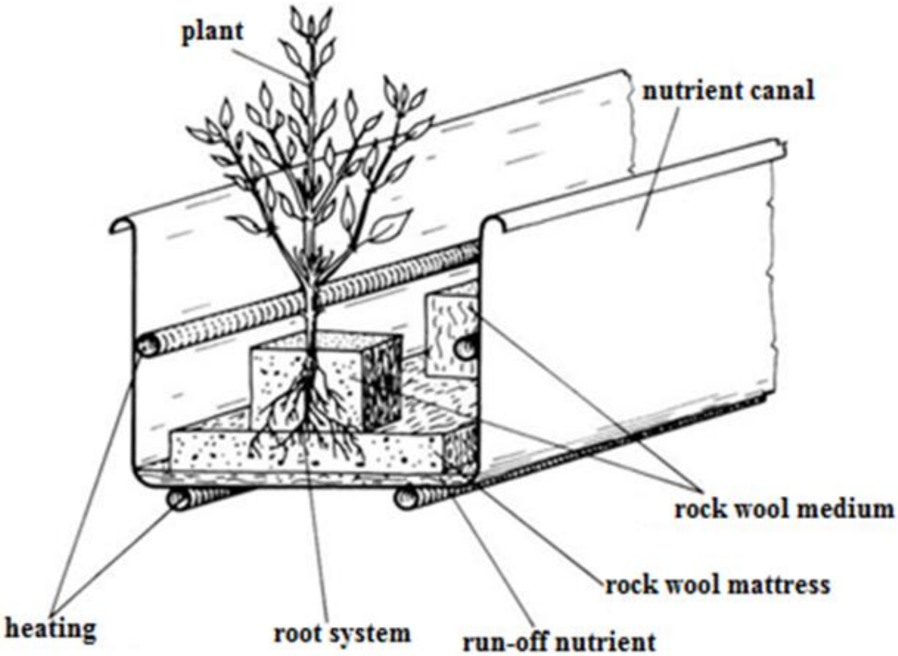


Figure 3. Soilless vegetable growing technology

The nutrient solution is dispensed by a completely automated system. The amount of nutrient solution is related to the growth of the plants. The composition of the nutrient solution is determined by robotic technology. The temperature is a very important factor, as well as the pH level and salt concentration of the solution. The supervision of these is the responsibility of the gardener. All plants are sensitive to salt (NaCl) stress, due to excessive salt most of them would die. The vegetables indicate nutrient deficiency by different discoloration or wilting.

- **Levels of nutrient supply of plants**

Deficiency: on many parts of the plant specific deficiency symptoms can be visible, crop failure occurs → "hidden hunger".

Critical: the concentration of the nutrient is *below* the level when the supplement of element results in yield growth. Fertilizer supplement is necessary.

Satisfactory: no yield growing → „luxury consumption"

Unnecessary, toxic: the concentration of element has negative effect on growing.

- **Fertilizer needs**

In many cases, soil can provide only a part of the necessary nutrients of the plant during the cultivation period. The defect of elements is shown by deficiency symptoms in the plant. Symptoms of deficiency are not diseases, but they can provide an entry for microbes. Therefore, we must supply the missing nutrient amount as soon as possible! The quantity of nutrients which meet the minimum nutrient requirement of the planned yield, is called manure need or fertilizer need. Often the soil has more nutrients than necessary, in this case the fertilizer need can be negative.

Table 3. Necessary elements

Elements	Uptake form and transport
	non-metallic elements
C carbon	CO2
H hidrogen	HCO3
O oxigen	H_2O
N nitrogen	NO_3^-, NH_4^+- ion
S sulfur	SO_4^{2-} ion
P phosphorus	P_2O_5
B boron	H3BO3
Si silicon	$Si(OH)_4$
	alkali metals and alkaline earth-metals
K potassium	K_2O
Na sodium	Na^+
Mg magnesium	Mg^{2+}
Ca calcium	
	heavy metals
Fe iron	Fe^{2+}
Mn manganese	MnO_4^{2} ion
Cu copper	Cu^{2+}
Zn zinc	Zn^{2+}

- **Importance of elements**

Nitrogen (N)

The nitrogen is present in the plant as amino acids or proteins or nucleotides or nucleic acids, additionally it is the most important component of chlorophyll. Elder plants cannot absorb the nitrogen in elementary form, it is absorbed as NO_3^- and NH_4^+ ion. Plants absorb more nitrogen to grow their vegetative parts. On sandy soils cultivated plants (root vegetables, potatoes, fruits) develop better by ammonium NH_4^+, other plants (cereals) prefer the nitrate NO_3^-. There are plants that grow equally well taking up both ions. Having the proper nitrogen supply the vegetative plant parts begin to grow and fruit ripening also will start. Shoots and leaves will be growing in deep green colour, healthily.

In case of nitrogen deficiency, the vegetative growing period will be short, while the reproductive period will be quicker. The growing of stem will be short and the stem will be thin. The lower leaves will be dull green, sometimes reddish or yellowish. The roots get elongated, with poor branches only. Product quality and quantity are below the expected results. The element nitrogen can be recycled element.

In case of nitrogen overdose the cereals bend, their resistance will be reduced e.g. against (*Fusarium spp.*). Plants cast off their flowers before fertilization, before fruit set. The tissue of grape vine is soft and spongy.

Nitrogen is present in the soil mostly in the form of compounds. The organic and inorganic nitrogen compounds constitute all the all nitrogen content of the soil and their transformation is a dynamic process determined by complex microbiological, soil and climatic factors.

Nitrogen is a reusable element. The nitrification is a process necessary for the nutrient supply of plants, in which the organic nitrogen changes to inorganic bound nitrogen. The nitrification happens in the presence of oxygen. So, the better the soil is ventilated, the more favourable the conditions for nitrification are. Nitrogen will be available for plants. The nitrogen cycling is opposite to process of mineralization. If the C-N ratio of the organic material is greater than that of the micro-organisms in the soil, than energy is necessary for nitrogen dissociation. In this case the microorganisms cover their needs from soil nitrogen. The nitrogen content of the soil is increased by the so-called nitrogen fixing plants. For example, nitrogen fixing bacteria live in symbiosis with the plant in the root of legumes and *Facelia*.

Ammonification: the amino-N transforms into ammonia by effect of bacteria ($R\text{-}NH_2$ – NH_4^+). During nitrification the ammonia with oxygen uptake transforms into nitrite and then converts into nitrate (by nitrate bacteria).

Phosphorus (P_2O_5)

The phosphorus has a major role in the development of the reproductive processes of plants. Primarily, it provides energy for the germination of seed, in ATP form. Later the seeds of fruits will absorb a significant amount of phosphorus. During vegetable forcing it can accelerate the process of rooting. This will increase the drought tolerance of young plants.

The phosphorus is present in plants both in organic and inorganic forms. Its inorganic form is the orthophosphoric acid H3PO4, or salts of calcium, magnesium and potassium. Plants absorb it in form of $H_2PO_4^-$. The uptake is influenced by the pH of the soil or nutrient solution. The low pH hinders the uptake of monovalent orthophosphate ions. The organic form is present in the nucleic acids (DNA). The nucleic acids take part in protein synthesis, cell division, in the transport of genetic material and in growth. Phosphorus can be recycled. The phosphorus cycle has two phases. In the first one, the phosphorus is absorbed into organic compounds then it disintegrates again into inorganic compounds in the environment. The plant material is partially returned into the soil then it will be an available element for plants again. Ploughing stubble-field, green manure and the tilling of root-remains have minimal role in the phosphorus cycle. The organic fertilizer has a direct role. It is present in the soil as phosphorus-peroxide P_2O_5. Its concentration depends on the soil type. Phosphorus is readily mobilized in plants.

In case of *phosphorus deficiency,* the element migrates from older tissues to meristem. We can observe the retarded growth of the plant. The stem and sprouts will be flimsy and leaves have deep red colouring.

Recalculation: P_2O_5 x 0.436 = P; P x 2.29 = P_2O_5.

Potassium (K_2O)

Out of the cations, it is the K^+ ion that plants contain in largest amount. It does not bind strongly to the cell, so the water can easily wash it out of the plant. They have plant physiological role in the synthesis of carbohydrates and starch. During vegetable forcing it promotes the colouring of tomato or sweet pepper. Biological cycle starts with the uptake by the roots of plants, then the smaller part will be absorbed into the plant, the greater part into the fruits. Ploughing stubble-field, green manure and the tilling of root-remains have minimal role in the potassium cycle. The greater part of potassium remains in the fruits, therefore the amount of potassium extracted by fruits can be supplemented by organic and chemical fertilizers. Potassium can be found mostly in clay minerals in soil. We know potassium providers and potassium binding clay minerals. The potassium needs of plants cultivated on potassium binding clay minerals cannot be satisfied until the potassium binding clay minerals are not saturated by potassium. It means a year-long, intensive fertilization with potassium. The potassium-providing ability of soils is different, it is determined by the formula K_2O. Although, the soil does not contain any potassium-oxide, it is a tradition to give the value of potassium providing ability of soil by potassium-oxide (AL= ammonium lactate method).

In case of *potassium deficiency,* the carbohydrate content of fruits, grapes and vegetables will be low. The fruits will colour poorly. The tip and the edges of the leaves get yellow, then brown and eventually they wither. The lamina is curled. The resistance of the cereals against the powdery mildew (*Erisyphe graminis*) will decrease.

Recalculation: K_2O x 0.83= K; K x 1.204 = K_2O.

Sulfur (S)

Cultivated plants contain a significantly smaller amount of sulfur than the above-mentioned macro-elements and yet it has an important role in the life of the plants. Among others it is a component of the sulfur-containing amino acids (cystine, cysteine, methionine), the koenzin-A, the vitamin H and it is present in the oil content of hemp, flax, soy and mustard as well. Plants absorb it in form of SO_4^{2} ion. The sulfate ion is built into the structure of protein, but it has a direct role in binding of bacteria *Rizobium* living on the root of legumes. The sulfur occurs in inorganic and organic form in soil. The organic sulfur content is in proportion with the soil humus content. The inorganic sulfur is present as gypsum $CaSO_4 \circ 2H_2O$, in saline soil as $NaSO_4$ and $MgSO_4$. In the sulfur cycling of soils the mineralization of organic matter has a central role. During mineralization released hydrogen-sulfite will be oxidized to elemental sulfur and to sulphate. In unventilated, pan soil the sulphate can be reduced to hydrogen sulfite, which is toxic to plants. It is possible that it forms iron sulfite with iron, which is insoluble. It inhibits the iron uptake.

In case of *sulfur deficiency,* the older leaves will be yellow or red. It is an anthocyanin pigmentation. In corn and cereal poor tillering, delayed ripening, and the short stem show the deficiency of the element. The growing of cruciferous plants (rape, mustard, and radish) is weak, young plants are stunted due to sulfur deficiency.

Calcium (Ca^{2+})

Calcium occurs in plants in form of salt of organic and inorganic acids and binding to ions of plasma colloids as well. The Ca^{2+}-ion with interaction the ß-indoleacetic acid have significant role in cell elongation and cell differentiation. It is a central component of the primary cell walls of medium plate, in which it has a stabilizer role. The plant physiological role of Ca^{2+} is direct in the development of the plasma membrane. The negative charge sites of pectin (*polygalacturonic acid*) connected like a bridge by calcium, thereby it significantly determines the stabilized of cell wall. Calcium has a role in hindering the changes caused by environmental effects, because the hormones transmitting the environmental effects provide the uninterrupted metabolic process with calcium. The hormone cannot get into the cell to induce metabolic changes as it bounds to receptors of cell membrane. The desired effect is mediated by using a calcium binding protein, *calmodulin*. The Ca^{2+} ions can be relatively easily transported with transpiration to xylem. Generally, they cannot be transported to phloem. Since the transport of calcium is poor, its return from leaves to stem and roots or from older parts to young plant parts is minor. Calcium is present in the soil in form of $CaCO_3$.

In case of *calcium deficiency*, the meristem tissue and the root hairs cannot grow. In apple fruit brown spots start up. On red pepper bells and tomato blossom-end rot develops. The buds of fruit trees cannot unsnap, the leaves curl up spoon shaped.

Magnesium (Mg^{2+})

The most important role of magnesium is in photosynthesis. Chlorophyll contains 27% magnesium. It can be found in protoplasm as a free ion. It participates in the development of the water balance of plants. Plants absorb it in form of Mg^{2+}. Magnesium has a direct role in the structure of enzymes and metabolism of phosphorus. Most part of magnesium is present in soil as silicates and carbonates. Major silicates are biotin, serpentine and olivine, while carbonates are magnesite and dolomite.

In case of *calcium deficiency* tissues of older leaves will be yellow between the veins (*chlorosis*), while the central vein remains green. Fan-shaped yellowing will start from the inside, which develops near the petiole between the central veins. The symptoms develop in every case on older leaves. But unlike nitrogen or potassium deficiency, it develops on the middle part or lower two-thirds of the stem. On the symptoms bright yellow, often purplish, reddish-orange colour is typical. The overdose of nitrogen, potassium or calcium and the low level of soil pH can increase the development of the symptom.

Iron (Fe^{2+})

The amount of iron in plants is an intermediate between macro and micro elements. Its physiological importance manifests during chlorophyll synthesis. The plant physiology effect of iron is primary in the process of respiration and photosynthesis. It is a central component of iron-containing plant enzymes. Plants absorb it in the form of chelate. It can be found in the crystal lattice of iron in soil, in relatively high amount. In sour soils the Fe^{3+} ions are in greater concentration. In neutral soil pH the Fe^{2+} ions precipitate as iron-hydroxide. In alkaline soil both forms precipitate.

In case of *iron deficiency* the plants perish by carbohydrate hunger due to inhibition of photosynthesis. The soil, under natural conditions, always contains enough iron therefore the symptom of chlorosis is of secondary origin, not iron deficiency. The cause of iron chlorosis is thought to be the disorder in the balance of Fe^{2+} and Fe^{3+}. In calcareous soils the iron is continuously removed from the soil solution due to the calcium carbonate, on sour soils it binds the phosphate. It is not the absolute iron content of plants that is important, it is the active form of available iron content. The top of the stem and the leaves of apple start yellowing, black spots appear on the leaves of pear, while the leaves of cherry are yellow, but the finest veins remain green. The symptom of chlorosis can also be caused by over irrigation.

Copper (Cu^{2+})

Copper has a primary role in photosynthesis, carbohydrate and protein metabolism, respiratory processes and in forming enzymes. Plants absorb it in form of Cu^{2+} ion. Iron, manganese and zinc are copper antagonists; these elements inhibit the uptake of copper. The copper concentration is very low in soil, 0.01 ppm. Its mobility is also small. In ionic form copper can quickly be absorbed by humic substances in soil. Copper deficiency can be observed in soils that are rich in organic matter.

Copper deficiency causes damage in the blooming fruit trees. the leaves of the young seedlings fall. It inhibits the growth of the internode of cereals and the crops remain frivolous in spike. The edges of older leaves die.

Manganese (Mn^{2+})

Many enzymes are activated by manganese. The oxidation of α-keto-glutaric acid, the decarboxylation of oxaloacetic and oxalic acid are realized by Mn^{2+} ions. The manganese has a primary role in photosynthesis and in the process of hydrolysis. Manganese has a favourable effect on the metabolism of carbohydrates, and it increases the Vitamin C content of vegetables. Plants absorb it in form of Mn^{2+} ion. The calcium is manganese antagonist. The plants contain very different concentrations of manganese. The amount of manganese of soil is highly dependent on the soil pH. In sour soils the manganese can accumulate in toxic amount. The manganese accumulates to the humus layer; therefore, manganese deficiency occurs mostly in chernozem and brown forest soils rich in organic matter.

Peas and spinach are sensitive to Manganese deficiency. On dicotyledonous plants mosaic chloroses will appear and later brown spots on leaves.

Zinc (Zn^{2+})

Zinc stimulates the growth of plants by auxin production. It participates in protein metabolism processes. Many enzymes are activated by zinc. Plants absorb it in form of Zn^{2+} ion, but in small amount. Phosphorus is zinc antagonist. Zinc occurs in soil as biotite, augite and in crystal lattice of several micas.

Cereals (pre-crop of vegetables) are not sensitive to zinc deficiency. However, the pop and sweet corn, beans, flax and hops respond sensitively to the deficiency of the element. The deficiency inhibits the budding of fruit trees, stems of apple remain bald.

Boron (H3BO3)

The physiological role of boron is complex, it has a primary role in the fertilisation of flowers and in crop production. It has important role in nutrients uptake and carbohydrates transport as well. It participates in the production of auxin. Boron is present as H3BO3 in the soil mica and other minerals. Plants absorb it as borate ion. The boron demand of monocots is less than that of the dicotyledonous plants. However, an overdose can be toxic to the plant. Soil liming can reduce the boron content of soil.

Most plants are sensitive to *boron deficiency*. Fertilization of grape cluster is defective. Boron deficiency can cause a wash-out symptom (heart rot) in sugar beet and cruciferous plants as well. In apple a fruit flesh rot symptom can develop due to boron deficiency.

Molybdenum (Mo)

Molybdenum is present in plants as metal component of several enzymes. Its plant physiological role in the N-metabolism is prominent. It participates in nitrate reduction, because it is the metallic creator of nitrate reductase enzyme. Plants absorb it in form of molybdate ion from soil. Sulphate ions are molybdenum antagonists. The molybdenum content of soils is very low, 0.5 to 10 ppm. The molybdenum concentration of sandy soils is very poor, however meadow soils are extremely rich. The molybdenum concentration of soil is in direct proportion with the reduction of soil pH, although the element binds to the soil strongly. Its transportability can be repaired by soil liming. The molybdenum demand of plants is different. The brassicas and legumes need more; however the grasses need less molybdenum.

In case of *molybdenum deficiency,* the content of sugar, chlorophyll and Vitamin C will be reduced. The petioles will extend (whip handle symptom).

Chapter 4

The grafting of vegetables

Picture 1. Grafted tomato

Grafting is a special horticultural technology, when tissues of plants are joined so as to continue their growth together. The grafting consists of two parts. The upper part of the combined vegetables is the scion, the lower part is called rootstock. For this, we must applicate a special low air space grafting tunnel.

The success of grafting depends on temperature, air humidity, light power and irrigation water quality, and also on the compatibility of scion and rootstock. The importance of grafting is a bigger resistance against physical factors (salt (NaCl), cool temperature, drought tolerance, nutrient uptake) and biological factors (fungi, bacterial infection). Better growing power and better yield quality can be expected. Grafting can be applied on dicotyledonous vegetables only, because it involves the joining of vascular tissues between the scion and rootstock, plants lacking vascular cambium, such as monocots, cannot normally be grafted. In Hungary the most common grafted vegetables are: sweet pepper, tomato, water melon and sugar melon. Rootstock breeding became a new sector of the horticulture.

Chapter 5

Vegetable cultivation on soil

Outdoor vegetable cultivation is the oldest form in horticulture. Taking advantage of the fertility of the soil, people cultivated plants already in ancient times. The fertile soil can provide optimal physical, chemical and biological conditions for plants, therefore, organized, conscious vegetable production developed through the interaction between soil and plant. Of course, mechanical tillage of the soil, crop rotation, nutrient supply, and some special features of outdoor vegetable production must be carried out every year, adapting to the needs of the given crop. The most important edaphic, ecological, agrochemical and microbiological factors for vegetable plants can be influenced by many factors during open field vegetable production. All processes of cultivation always follow the biological cycle of the plant, which we will discuss in detail in our work. We analyse the advantages and disadvantages of growing vegetables in the field in a few thoughts.

Summary:

- all vegetables can be grown in the right season,
- we can also use organic manure, industrial waste, mineral fertilizers, bacterial fertilizers, green manure and compost as nutrient supplement, therefore reducing the use of artificial fertilizers,
- due to the use of crop rotation, pathogens and pests spread less,
- crop rotation improves soil structure,

- crop production can be carried out efficiently with large-scale machinery only,
- super quality and marketability but lower yield,
- it is suitable for organic farming,
- successful cultivation depends on weather,
- only seasonal cultivation,
- application of irrigation equipment is essential,
- it also requires a lot of human work.

Picture 2. Open-field vegetable cultivation

Nowadays, the area of open-field vegetable production is decreasing. Open-field vegetable production has fallen back compared to intensive vegetable growing. Of course, we have some vegetable plants that are grown mostly on the open field, such as: watermelon, sugar melon, onion, garlic, red pepper, pumpkin, beans and peas. Vegetable crops grown in open field production are mostly processed in canneries. About 25-35 types of vegetables are grown in Hungary, but only 9-10 of these plants account for 90% of production and consumption.

All vegetables are a natural source of some essential nutrient, which can enter together with other vitamins in human body. From this aspect, the market demands the healthiest, freshest, pesticide-free produce. It is therefore important, that students learn about the most effective vegetable cultivation on soil.

- **Soil covering**

The water content of soil is a very important factor for successful cultivation. In order to hold water in the soil, we apply soil covering technology.

Picture 3. Soil covering

The soil can be covered with:

- mulch,
- straw,
- plastic,
- special ice-resistant plastic.

- **Vegetable growing in container**

The container technology is a more modern, more efficient form of vegetable growing. The size of the container should always be chosen according to the root mass of the given culture. We can ensure the nutrient supply with the help of a computer system. The characteristics of container technology are as follows:

- the gardener can prepare the optimal soil for the plant, which can be mixed with compost and reused from the second year after cultivation,
- the harvested plants can be composted and mixed with the soil, and then reused,
- super quality and good yield,
- we can use organic and artificial fertilizers, bacterial and mineral fertilizers for nutrient supply,
- biological plant protection can be used during the total cultivation,
- very high initial investment costs (expensive),
- it claims a professional gardening knowledge.

Picture 4. Tomato growing in container

- **The water requirement of plants**

During the growing season the water requirement is different by species and varieties. The extent of water consumption is varied too. In this, the actual water needs of plant, the meteorological, the ecological and technological factors have role. The water needs of plant are characterized by transpiration coefficient. It determines the necessary water amount to produce a unit of dry matter. The water requirement of C3 and C4-type plants are different. This also means, that the precipitation can't cover the necessary water requirement of the plant. Therefore the plant must use winter precipitation stored in the soil but they also need irrigation.

- **The nutrient requirement of plants**

The nutrient needs of the plant are determined by necessary nutrient amount, which the plant must absorb to reach for characteristic yield of plant. The nutrient needs are defined by the weight of the yield in general (100-1000 kg; m^2). The nutrient needs per yield weight unit is called specific nutrition needs. To reach the planned yield, we must satisfy the nutrient needs of the plant. The nutrient needs are calculated by a concrete element in each case. Consequently we can speak of N, P, K, Ca, Mg etc. needs. The cultivation technology, the ecological conditions and the missing element have effect on the quality and quantity of the yield. In general, not all of the harvested parts of plants are utilized. The directly utilized plant part is called main product, while the residual parts are the by-products. The specific nutrient needs of the plant can be calculated by the following equation:

$$\textbf{Specific nutrient needs (kg/t)} = \frac{\textbf{nutrient content of main product + nutrient content of by-product}}{\textbf{mass of main product}}$$

- **Fertilizer needs**

The soil in many cases can provide only a part of the necessary nutrient of the plant during cultivation period. The defect of elements is showed by deficiency symptom in the plant. Symptoms of deficiency are not diseases, but they can provide an entry for microbes. Therefore, we must supply the missing nutrient amount as soon as possible! The quantity of nutrients which meet the minimum nutrient requirement of the planned yield, is called manure or fertilizer need. Often the soil has more nutrients as necessary, in this case the fertilizer needs can be negative.

- **Contexts of nutrient requirements and fertilizer needs**

The plant can produce the high quality and optimum yield not only during cultivation on soil. If the nutrient needs of plant are provided by nutrient solution, then the nutrient need and fertilizer need of the plant will be the same. One example for this is the intensive, soil less forcing of vegetables. We can draw the conclusion that we must fertilize the plant, and not the soil. The fertilization of the soil without plant cultivation would be a pointless activity. The original nutrients and supplemented nutrients of the soil are available for the plant. In this sense the soil is not a neutral medium, it is a biologically and chemically it is active reactant for fertilizers. The reactivity of fertilizer is greater like that of the manure. The nutrient content of the fertilizer must cover the nutrient needs of the plant. The fertilizer overdose of soil can bring about ion antagonism or dangerous element accumulation (e.g. $NH_4^+ \rightarrow NO_3^- \rightarrow NO_2^-$).

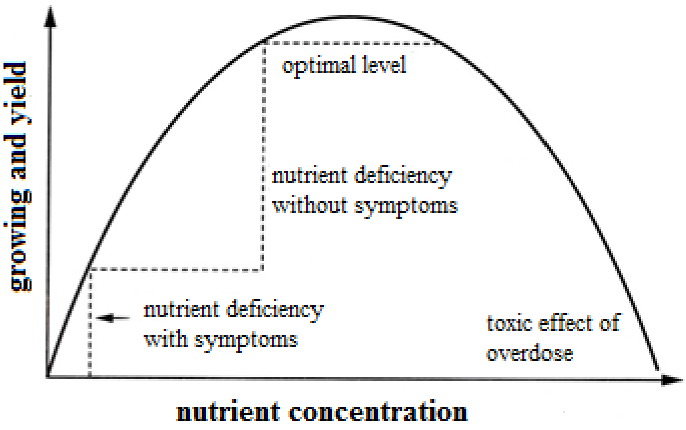


Figure 4. Nutrient requirement

*

Chapter 6

Propagation of vegetables

Vegetable plants are most often propagated by seed, generatively method. There are some vegetable plants that are propagated from one of their vegetative organs (e.g. asparagus). Early potatoes can be propagated from tubers, garlic from cuttings and horseradish from rootstocks. The properties of the seed fundamentally determine the success of cultivation. It is important that the seeds being sown are of uniform size, otherwise germination will be uneven. We must always provide optimal conditions for germination to ensure an adequate, healthy number of germs.

- **Sowing**

Picture 5. Sowing in peat

When determining the sowing date, we must primarily strive to ensure the best germination conditions for the sown seed. We must precisely determine the depth and method of sowing. Seeds of cold-hardy plants (carrots, parsley, lettuce, radishes, spinach, onions) should be sown at early spring. Especially in the case of slow-germinating seeds, we must adhere to the earlier sowing time (carrots, parsley, onions).

Table 4. Characteristics of seeds

Vegetable	1000 seed weight (g)	germination (day)	germination capacity (year)
sweet pepper	3-6	10	4-5
tomato	2-3	12-16	3-4
cucumber	20-25	5-8	6-8
cabbage	3-6	10	4-5
water melon	100-300	10-14	6-8
sugar melon	20-30	6-8	6-8
carrot	1.2-1.5	16-21	3-4
parsley	1.2-1.8	20-28	2-3
onion	3-4	10-12	3-4
lettuce	0.8-1	6-8	4-5
bean	100-600	8-10	3-5
pea	120-400	8-10	3-5
celery	0.3-0.5	20-21	3-4
pumpkin	150-200	6-8	6-8
beetroot	13-22	10-14	3-4
radish	6-10	6-10	4-5

- **sowing preparation**

- seed control (form, germination, resistance),
- selection of sowing box,
- sifting of peat,
- irrigation water,
- ensure of temperature,
- ensure of light,
- plant protection

seed needs:

$$\frac{\text{sowing area (m}^2\text{) x plant density (plant/m}^2\text{) x 1000 seeds weight}}{\text{10 x germination capacity (\%)}}$$

Practice:

In a family farm, we would like to grow tomato shape peppers in a 900 m^2 plastic tunnel. 1000-seed weight of 6 g. We plan a planting density of 12 plant/m^2. The seeds have a germination capacity of 85%.

How many seeds will we need to plant the plastic tunnel?

seed needs:

$$\frac{900 \times 12 \times 6}{10 \times 85} = \frac{64800}{850} = 76.2 \text{ g}$$

- **seedling growing**

We use peat soil with a high humus content for seedling cultivation. pH level must be neutral. Free from pathogens and pests! For growing of root mass, the seedlings need a large amount of phosphorus, and for further vegetative growth, it needs nitrogen. Seedlings are grown in so-called peat cubes.

Table 5. Size of peat cubes

Vegetables	Size (cm)
sweet pepper, red spice pepper, celery, parsley, carrot	3-5
tomato, cucumber	6-8
lettuce, kohlrabi	4-5
cabbage, cauliflower	5-6
water melon, sugar melon, pumpkin	7-8

- **Optimal temperature**

According Markov and Haev, we must ensure the optimal temperature for vegetables in order to successful growing during the total cultivation.

25 ± 7 °C – cucumber, sweet pepper, water melon, sugar melon, pumpkin

22 ± 7 °C – tomato, green bean, egg plant

19 ± 7 °C – onion, garlic, celery, beetroot, asparagus

16 ± 7 °C – carrot, parsley, lettuce, pea, sorrel, spinach

13 ± 7 °C – cabbage, radish, horse-radish

Sweet pepper (*Capsicum annuum* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Solanales
Family:	Solanaceae
Subfamily:	Solanoideae
Tribe:	Capsiceae
Genus:	*Capsicum*

Its gene center is South America (Brazil, Peru, Guatemala). After the discovery of America, it was introduced in Europe and Asia. It has been cultivated and bred in Hungary since the 16th century. Its most important cultivation area is Southern Great Plain, Szentes and its surroundings.

It is an annual, dicotyledonous, long-day, herbaceous plant.

Root

The axis of its main root is a strong taproot, on which dense, branching lateral roots develop. Most of the roots are located close to the soil surface, about 30-40 cm deep.

Stem

The stem is initially soft, later becoming woody. Its shoot system is continuously growing or determinate, branching above the ground in a forked manner.

Leaf

Simple, with entire margins, heart-shaped. Leaf attached to the stem by petiole.

Flower

Unisexual, white or purple, panicle inflorescence. Self-fertile, but bumblebees improve the degree of fertilization during pollination.

Fruit

Berry crop. Its shape can be varied (long, tomato, apple, cherry shaped). In it we find the seeds, which are flat, yellow, kidney-shaped. They retain their germination capacity for 3-4 years.

Cultivability

We can cultivate outdoor on field, under plastic tunnel on soil, and in container or in rock wool in green house. Sweet peppers are grown from seedlings.

Its harvesting is carried out by hand or mechanically in different time.

Harvest time of outdoor cultivation: from May to November.

heated greenhouse growing: all year round.

unheated plastic tunnel: from April to November.

Cultivation requirements

- medium-hard, airy, rapid warming soil, brawn sand, pise or chernozem soils,
- heat-requiring, (Markov-Haev 25± 7 °C), seed germination optimum 30-32 °C,
- light requirement 5000 lux, long-day plant,
- water-intensive, requires regular irrigation during cultivation (450 mm),
- organic manure requirement 40-50 t/ha, fertilizer N: 2.4 kg P_2O_5: 0.9 kg K_2O: 3.4 kg for 1000 kg yield,
- calcium nitrate fertilizer, with added pet salt,
- it requires regular phytotechnical operations: loosening the soil, weed control, tying, green pruning.

Plant protection

Rhizochtonia solani,

Sclerotinia sclerotiorum,

Leveillula taurica,

Xantomonas vesicatoria,

Pseudomonas viridiflava,

Tabacco Mosaic Virus,

Cucumber Mosaic Virus

Meloidogyne hapla,

Gryllotalpa gryllotalpa,

Agriolimax agrestis,

Frankliniella occidentalis,

Trialeurodes vaporariorum,
Helicoverpa armigera,
Aphidideae,
Tetranychus ultricae

Effect on human body

Sweet pepper contains a number of bioactive materials, vitamin C, B, A, carotenoids, polyphenols and sugar (fructose and glucose) in high concentration. Hot pepper contains capsaicin materials. It is a very good antioxidant; it regulates the blood pressure and helps metabolism. The fibre of sweet pepper is easily digestible.

Spice red pepper (*Capsicum annuum* L. *var. longum*)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Solanales
Family:	Solanaceae
Subfamily:	Solanoideae
Tribe:	Capsiceae
Genus:	*Capsicum*

Its gene center is South and Latin America and Mexico. After the discovery of America, it was introduced in Europe and Asia. It is very popular in China, Turkey and Arabic world. It has been cultivated and bred in Hungary since the 17th century. Its most important cultivation areas are Szeged and Kalocsa.

It is an annual, dicotyledonous, long-day, herbaceous plant.

Root

The axis of its main root is a strong taproot, on which dense, branching lateral roots develop. Most of the roots are located close to the soil surface, about 30-40 cm deep.

Stem

The stem is initially soft, later becoming woody. Its shoot system is continuously growing or determinate, branching above the ground in a forked manner.

Leaf

Simple, with entire margins, heart-shaped. Leaf attached to the stem by petiole.

Flower

Unisexual, white or purple, panicle inflorescence. Self-fertile, but bumblebees improve the degree of fertilization during pollination.

Fruit

Elongated shaped crop. Its shape can be varied (long, tomato, apple, cherry shaped). In it we find the seeds, which are flat, yellow, kidney-shaped. They retain their germination capacity for 3-4 years.

Cultivability

We can cultivate outdoor on field, under plastic tunnel on soil, in container in green house. Spice red peppers are grown from seedlings or seed.
Its harvesting carried out by hand or mechanical from August to September.
Time of outdoor cultivation: from May to September.
Time of unheated plastic tunnel: from April to September.

Cultivation requirements

- medium-hard, airy, rapid warming soil, brawn sand, pise or chernozem,
- heat-requiring, (Markov-Haev 25 ± 7 °C), seed germination optimum 30-32 °C,
- light requirement 5000 lux, long-day plant,
- water-intensive, requires regular irrigation during cultivation (450 mm),
- organic manure requirement 40-50 t/ha, fertilizer N: 2.4 kg P_2O_5: 0.9 kg K_2O: 3.4 kg for 1000 kg yield,
- calcium nitrate fertilizer, with added pet salt,
- it requires regular phytotechnical operations: loosening the soil, weed control, tying

Plant protection

Rhizochtonia solani,

Sclerotinia sclerotiorum,

Leveillula taurica,

Xantomonas vesicatoria,

Pseudomonas viridiflava,

Tabacco Mosaic Virus,

Cucumber Mosaic Virus

Meloidogyne hapla,

Gryllotalpa gryllotalpa,

Agriolimax agrestis,

Frankliniella occidentalis,
Trialeurodes vaporariorum,
Helicoverpa armigera,
Aphidideae,
Tetranychus ultricae

Effect on human body

Spice pepper contains a number of bioactive materials: vitamin C, B, A, carotenoids (capsanthin, cabsorubin, β carotene, violaxanthin, lutein) polyphenols and sugar (fructose and glucose) in high concentration. The hot pepper contains capsaicin materials. It is a very good antioxidant, it regulates the blood pressure and helps metabolism. Powder of spice red pepper is easily digestible.

Tomato (*Solanum lycopersicum* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Solanales
Family:	Solanaceae
Genus:	*Solanum*
Species:	***S. lycopersicum***

Its genetic center is South America, Peru and Bolivia. It was only introduced in Hungary at the end of the 17th century. Its cultivation and propagation in arable land began in the 20th century. Its most important cultivation areas are Southern Great Plain, Szentes and Fábiánsebestyén.

It is an annual, dicotyledonous, long-day, herbaceous plant.

Root

Strongly developed taproot, characteristic of which is that it easily develops adventitious roots from the stem.

Stem

Cylindrical, covered with hairs. Later, ribs develop on the stem, which strengthen the stem. Its shoot system can be continuously growing, semi-determinate and determinate.

Leaf

Semi-pinnate, attached to the stem by a petiole. Its surface is hairy.

Flower

Yellow colored. It can be heterosexual or monoecious. The bumblebees carry out its fertilization. Its inflorescence is a raceme, in which a different number of flowers can develop.

Fruit

Very juicy berry. Its shape is varied, it can be ball, flattened, spherical or elongated shaped. It contains small seeds, which are beige in color, flattened and have a fluffy surface. They retain their germination ability for 3-4 years.

Cultivability

We can cultivate it outdoor on field, under plastic tunnel on soil, in container or in rock wool in green house. Tomato is grown from seedlings. Its harvesting carried out by hand or mechanical in different time.
Time of outdoor cultivation: from May to November.
Time of heated greenhouse growing: all year round.
Time of unheated plastic tunnel: from April to November.

Cultivation requirements

- medium-hard, airy, rapid warming soil, brawn sand, pise or chernozem soils or soilless technology,
- heat-requiring, (Markov-Haev 22 ± 7 ^{o}C), seed germination optimum 22-25 ^{o}C,
- light requirement 5000 lux, long-day plant,
- water-intensive, requires regular irrigation during cultivation (500-600 mm),
- organic manure requirement 40-50 t/ha, fertilizer N: 3.2 kg P_2O_5: 0.9 kg K_2O: 6.3 kg for 1000 kg yield,
- calcium nitrate fertilizer, with added pet salt, EC 2,
- it requires regular phytotechnical operations: loosening the soil, weed control, tying, green pruning.

Plant protection

Rhizochtonia solani,

Sclerotinia sclerotiorum,

Xantomonas vesicatoria,

Erysiphe orontii,

Tomato Mosaic Virus,

Phytophtora infestans,

Botrytis cinerea,

Alternaria porri

Meloidogyne hapla,

Gryllotalpa gryllotalpa,

Agriolimax agrestis,

Frankliniella occidentalis,
Trialeurodes vaporariorum,
Helicoverpa armigera,
Aphidideae,
Tetranychus ultricae

Effect on human body

Tomato contains a number of bioactive materials: vitamin C, B, A, carotenoids (lycopene, β carotene, violaxanthin, lutein) polyphenols and sugar (fructose and glucose) in high concentration. It is very good antioxidant, it helps metabolism. The fibre of tomato is easily digestible. The nutritional value of cooked tomato is significantly higher because the heat releases lycopene from the fibers. The lycopene is very good anti-inflammatory. A medicinal substance has been extracted from its alkaloid called tomatine to treat fungal diseases.

Cucumber (*Cucumis sativus* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Cucurbitales
Family:	Cucurbitaceae
Genus:	*Cucumis*
Species:	***C. sativus***

Its genetic center is South China and India. It was only introduced in Hungary at the end of the 19th century. Its cultivation and propagation in arable land began in the 20th century. Its most important cultivation area is Southern Great Plain, Kecskemét.

It is an annual, dicotyledonous, long-day, herbaceous plant.

Root

Well-developed 80-100 cm long taproot. It develops a large number of root branches close to the soil surface.

Stem

Its surface is covered with hairs, with a square cross-section. Its length can be 1-2-5 m, depending on the variety. Its stem system is a recumbent, which is tied up during growing.

Leaf

Large, palmately lobed, with a hairy surface. The leaf is attached to the stem by a long, angular petiole.

Flower

Its predominantly yellow petals are fused together, their upper edge is divided into 5-6 lobes. Originally it is dioecious, unisexual, the ratio of male and female flowers can be 1:8. Flower types:

Monoecious

Only male flowers develop on the lower 10-14 nodes, followed by female flowers on the main stem. This is called a mixed-flowering cultivar type.

Gynoecium

In this type, male flowers can only be produced on the first node, while the rest are exclusively female. This increases the fertility of these types. This is called an all-female cultivar.

Predominantly female-flowered

Variety Flower formation begins with male flowers, and then only female flowers develop from nodes 7-10.

Fruit

Cucumber. It can be a delicacy cucumber (for canning, less than 14 cm), a salad cucumber (14-30 cm), and a snake cucumber (over 30 cm). Its seeds are white, pointed at the end, and flat. It retains its germination capacity for 8 years.

Cultivability

We can cultivate it outdoor on field, under plastic tunnel on soil, in container or in rock wool in green house. Cucumber is grown from seedlings. Its harvest is carried out by hand or mechanically in different time.

Time of outdoor cultivation: from May to September.

Time of heated greenhouse growing: all year round.

Time of unheated plastic tunnel: from April to October.

Cultivation requirements

- growing temperature 25 ± 7 °C ; germination temperature 26-28 °C,
- loose structure, rapidly warming, humus or brawn sandy soil,
- 700-800 mm water (during the total growing),
- 70-80% air humidity,
- at least 12 hours sunshine per day (5000 Lux light),
- nutrient: **3** kg N; **1.5** kg P_2O_5, and **4** kg K_2O for 1000 kg yield.
- Mg, Ca, Fe, Cu, B supplement.

Cultivation of pickled cucumbers in the open field

Mainly carried out on large-scale farms by sowing seeds of monoecious varieties. For this, for example, the Perez F_1 and Mohican F_1 varieties are excellent. Field sowing can be done by machine or, in rare cases, by hand.

In Bulgarian horticulture, the seeds were pre-germinated in a water mill the day before sowing, thus accelerating germination and saving on leavening irrigation. The seeds are sown in mid-May, in a well-prepared, moist seedbed with loose soil. The sowing depth is 3 cm, and the arrangement can be single-row 100 x 120 cm or twin-row 160 + 40 cm. Seed requirement 3-4 kg/ha, depending of variety.

Cultivation of salad cucumber

Seeds are sown under frameless foil cover at the end of April. The foil cover remains on the plants for 1 month, then it is removed. Take care to avoid sunburn. Lettuce can also be grown from seedlings, by planting seedlings in nutrient cubes at the end of April. The time for sowing without foil cover is mid- to late May. After this, irrigate with a leavening agent. The nutrient supply should be applied together with the irrigation water.

.

Intensive cucumber growing

In our country, cucumbers are grown as a vegetable. The initiation of growing can be done with planting in November until June, planting in February until the end of July, and planting in August until December. When growing cucumbers, we must maintain the appropriate temperature at night (18 °C), otherwise symptoms of downy mildew will easily develop on the leaves!

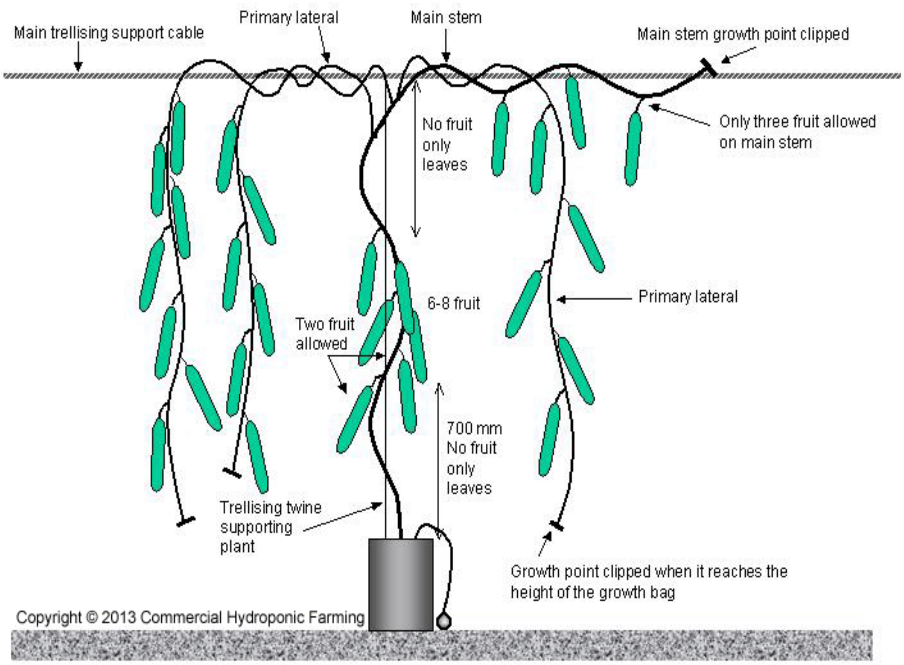


Figure 5. Green pruning of intensive growed cucumber

Plant protection

Rhizochtonia solani,

Sclerotinia sclerotiorum,

Sphaerotheca fuliginea,

Phytophtora infestans,

Botrytis cinerea,

Pseudoperonospora cubensis,

Cladosporium cucumerinum

Meloidogyne hapla,

Gryllotalpa gryllotalpa,

Agriolimax agrestis,

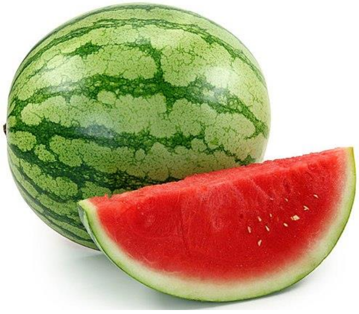
Frankliniella occidentalis,
Trialeurodes vaporariorum,
Helicoverpa armigera,
Aphidideae,
Tetranychus ultricae

Effect on human body

Cucumbers contain mostly easily absorbable potassium, which helps the kidneys function. Their nutritional value is not high, as they contain at least 80% water. They do not have an excessive diuretic effect. In addition to canning industry, cucumbers are most widely processed by cosmetics industry. The lysozyme they contain is an antibiotic enzyme that is used as a skin-care cosmetic. The vitamin C content is low, but they contain several essential vitamins, such as the fat-soluble vitamins H, A, E, F, and a type of vitamin B and panthenol.

Watermelon (*Citrullus lanatus* Thomb.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Cucurbitales
Family:	Cucurbitaceae
Genus:	*Citrullus*
Species:	***C. lanatus***



Its gene center is southern Africa, in Europe only in the Mediterranean parts, or warm, sunny areas. In Hungary, established watermelon-growing areas are Heves, Csány, Békés, Magyarbánhegyes, Medgyesegyház. Watermelons are not widely greenhouse-forced in Hungary, but their cultivation on the open field is very popular.

It is an annual, dicotyledonous, long-day, herbaceous plant.

Root

The germinating seed develops a strong taproot, which can penetrate the soil up to 150 cm deep. The taproot develops numerous lateral roots, on which we find numerous secondary branches, therefore the bulk of the root system is located in the upper 25 cm layer of the soil.

Stem

The stem is a slightly hairy, recumbent stem. Its cross-section can be round or square. The shoot system is continuously growing, determinate or semi-determinate. The loop developing on the stem serves for climbing.

Leaf

A multi-partite leaf blade, attached to the stem by a long petiole. Its surface is covered with a layer of wax. The division of the leaf may vary depending on the variety.

Flower

There are three types of flowers in watermelons. Male, hermaphrodite and female flowers. Fruiting flowers are external pollinated, and are fertilized by insects. Depending on the variety, 10-20 fruiting flowers develop on the plants.

Fruit

Fruit is pepo. The watermelon contains 80-85% water. The seeds are located in the pericarp. They retain their germination capacity 6-8 years. Triploid watermelon does not form seeds. Its skin can be uniform, wrinkled, broadly or narrowly marbled. Its shape can be globose, oval, cylindrical, or pear-shaped.

Cultivability

We can cultivate it outdoors on field, under plastic tunnel or on soil in green house. Watermelon is grown from grafted seedlings. Its harvest is carried out by hand in different time.

Time of outdoor cultivation: from May to August.

Time of heated greenhouse growing: all year round.

Time of unheated plastic tunnel: from April to June.

Cultivation requirements

- growing temperature 25 ± 7 °C ; germination temperature 30 °C,
- loose structure, rapidly warming, humus or brawn sandy soil,
- 700-800 mm water (during the total growing),
- 70-80% air humidity,
- at least 12 hours sunshine per day (7000 Lux light),
- nutrient: 2.4 kg N; 1.1 kg P_2O_5, and 5.6 kg K_2O for 1000 kg yield.
- Mg, Ca supplement.

Growing of watermelon on outdoors

Watermelon can be grown by seeding or from seedlings. With seedlings, earliness and the growth period can be extended. The watermelon can be grown more efficiently with grafted seedlings. Good rootstocks include butternut squash, pumpkin, and wax gourd. The seedling growing period is 5-6 weeks. Seeds can be sown with pre-germinated, swollen and dry seeds. Seed requirement is 0.6-0.8 kg/ha. The next important step is to keep the seeds warm.

Plant protection

Watermelon Mosaic Virus*,*

Fusarium oxisporum,

Erysiphe cichoracearum,

Pseudoperonospora cubensis,

Didymella bryoniae

Meloidogyne spp.,

Gryllotalpa gryllotalpa,

Tetramorim caespitum,

Limacidae,

Trips palmi,

Aphis gossypii,

Lepus europaeus

Effect on human body

The best dietary effect of watermelon is in its high water content. Due to its high water and low calorie content (29 kcal/10 dkg), it is a favorite of dieters. It is excellent for emptying the intestines and removing waste products quickly. Watermelon is rich in potassium, folic acid, vitamin A and the antioxidant lycopene. Lycopene promotes hormonal processes, but inhibits cholesterol synthesis, thereby reducing cardiovascular diseases. It has an outstanding diuretic effect. Consume it pleasantly chilled.

Melon (*Cucumis melo* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Cucurbitales
Family:	Cucurbitaceae
Genus:	*Cucumis*
Species:	***C. melo***

Its genetic center is Iran, Armenia but it is also considered native to tropical Africa. In Hungary, it is cultivated in Heves, Békés, Baranya, Tolna, Debrecen and the Nyírség region. Its greenhouse forcing has only become less widespread.

It is an annual, dicotyledonous, long-day, herbaceous plant.

Root

The germinating seed develops a strong taproot, which can penetrate the soil up to 150 cm deep. The taproot develops numerous lateral roots, on which we find numerous secondary branches. The bulk of the root system is thus located in the upper 25 cm layer of the soil.

Stem

The stem is a slightly hairy, recumbent stem. Its cross-section can be round or square. The shoot system is continuously growing, determinate or semi-determinate. The loop developing on the stem serves for climbing.

Leaf

A multi-partite leaf blade, attached to the stem by a long petiole. Its surface is covered with a layer of wax. The division of the leaf may vary depending on the variety.

Flower

There are three types of flowers in melons. Male, hermaphrodite and female flowers. Fruiting flowers are external pollinated, and are fertilized by insects. Depending on the variety, 10-20 fruiting flowers develop on the plants.

Fruit

Fruit is pepo. The melon contains 80-85% water. The seeds are located in the pericarp. They retain their germination capacity 6-8 years. Triploid melon does not form seeds. Its skin can be uniform, wrinkled, broadly or narrowly marbled. Its shape can be globose, oval, cylindrical, or pear-shaped.

Cultivability

We can cultivate it outdoors on field, under plastic tunnel or on soil in green house. Melon is grown from grafted seedlings. Its harvest is carried out by hand in different time.

Time of outdoor cultivation: from May to August.

Time of heated greenhouse growing: all year round.

Time of unheated plastic tunnel: from April to June.

Cultivation requirements

- growing temperature 25 ± 7 °C ; germination temperature 30 °C,
- loose structure, rapidly warming, humus or brawn sandy soil,
- 700-800 mm water (during the total growing),
- 70-80% air humidity,
- at least 12 hours sunshine per day (7000 Lux light),
- nutrient: 2.4 kg N; 1.1 kg P_2O_5, and 5.6 kg K_2O for 1000 kg yield.
- Mg, Ca supplement.

Growing of melon on outdoors

Melons can be grown by seeding or seedlings. With seedlings, earliness and the growth period can be extended. Melons can be grown more efficiently with grafted seedlings. Good rootstocks include butternut squash, pumpkin, and wax gourd. The seedling growing period is 5-6 weeks. Seeds can be sown with pre-germinated, swollen and dry seeds.

Plant protection

Watermelon Mosaic Virus,

Fusarium oxisporum,

Erysiphe cichoracearum,

Pseudoperonospora cubensis,

Didymella bryoniae

Meloidogyne spp.,

Gryllotalpa gryllotalpa,

Tetramorim caespitum,

Limacidae,

Trips palmi,

Aphis gossypii

Effect on human body

Melon is significantly richer in nutritional value than watermelon. Due to its high sugar (fructose and glucose) content, it cannot be used in weight loss diets. It has a high ß-carotene content. The vitamin content relieves inflammation of the mucous membrane in case of colds. The combined effect of ß-carotene and vitamin A is effective in the treatment of menstrual disorders.

Onion (*Allium cepa* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Monocots
Order:	Asparagales
Family:	Amaryllidaceae
Subfamily:	Allioideae
Genus:	*Allium*
Subgenus:	*A.* subg. *Cepa*
Species:	***A. cepa***

Its genetic center is Central Asia, and it also occurs wild on its native land. In Hungary, it can be cultivated throughout the country, but its most important production area is Makó.

It is a perennial, herbaceous, short-day plant. However, when grown in cultivation, it is considered a biennial plant. Its light requirement gradually increases during its development.

Root

Tufted root system, most of which are taproots. They are located at the base of the onion stem, but do not penetrate the soil deeply.

Stem

The underground, lower, widened part of the stem, consisting of several fleshy leaves and dry bracts, forms the onion bulb.

Leaf

The leaves above ground are erect, semi- or fully cylindrical. They are hollow inside and covered with wax on the outside.

Flower

A spherical umbel inflorescence consisting of many small flowers.

Fruit

A capsule. Its seeds are small and black. They retain their germination capacity 2 years.

Cultivability

The onion is grown as one or two-year-old plants. Accordingly, they are propagated from seeds or cuttings. Only *Class I* cuttings are used in growing equipment. Its early sprouting is less justified, as its heat requirement is low, so it can be grown in the field with great safety. It also develops quickly when planted in protected soil in autumn or at the end of winter.

Cultivation requirements

- growing temperature 19 ± 7 °C ; germination temperature 4-6 °C,
- loose structure, rapidly warming, humus or brawn sandy soil,
- 200-300 mm water (during the total growing),
- 70-80% air humidity,
- medium light requirements, but prefers long daylight hours during its development,
- nutrient: 3.8 kg N; 1.2 kg P_2O_5, and 4.2 kg K_2O for 1000 kg yield.
- magnesium sulfate supplement.

Bulb cultivation

In the first year of bulb cultivation, the propagation material is grown. For this, 80-100 kg of seeds are sown per hectare in March. The seeds are sown relatively densely, with a row spacing of 20-25 cm, at a depth of 5 cm. At this density, the size of the bulbs remains small, so they can be propagated further as bulbs. The bulbs are expected to mature by the end of July, at which time they are picked up by machine, cleaned and then graded. The leveled bulbs are stored in raschel bags in a ventilated place. The bulbs are planted in March of the following year by machine or by hand with a planting stick. The bulbs need well-prepared, loose soil. During planting, 800-1000 kg/ha of propagation material is needed, which is planted 6-8 cm deep. The bulbs should sprout within 2 weeks of planting.

Seed breeding

When grown from seed, onions are sown in the II. –IV. months. Since the seeds are small, they require shallow sowing. The row spacing is 25-30 cm, depending on the mechanical cultivation. The seeds should germinate 20-25 days after sowing. Onion weeding is done with a pre-emergent herbicide or a hand hoe. Weeding is done at least 2 times during the onion growing season. In case of dry, extreme weather, irrigation may be necessary to ensure the effectiveness of the chemical.

Harvest

Onions are harvested when the stem is biologically ripe. This is indicated by the onion wilting and drooping its leaves. This can be expected in August if grown from bulbs, and in September if grown from seeds. The onions are harvested by machine in two passes. In the first pass, the picking machine lifts the ripe onions and then stacks them in rows. After a few days of drying, the onions are picked by the stacking machine. The onions are transported to a storage facility, where they are protected from possible rotting by ventilation.

Onion seed production is done in two or three rounds. This work is mostly done in the seed research institute. In the case of the two-year seed production technology, the corm is grown from seed in the first year. It is necessary that the corm fully carries the appropriate 60 varietal characteristics. This can be achieved through strict selection work. The selected corm is planted in autumn, and then in the second year it sprouts into a seed stalk and ripens seeds. In the case of the three-year technology, mother bulbs are grown from the bulbs in the second year, which are selected and then planted in autumn. In the third year, the onion ripens to seed.

Plant protection

Burkholderia cepacia,

Fusarium oxysporum,

Botrytis allii,

Peronospora destructor,

Ditylencus dipsaci,

Delia antiqua,

Napomyza gymnostoma,

Suillia univittata,

Acrolepia assectella

Effect on human body

Onion is used in Hungarian cuisine for almost every dish. In addition to its pleasant aroma and seasoning role, it is also suitable for treating colds due to the bactericidal effect of the sulfur-containing allyl sulfide in the fleshy leaves. The onion stem also contains vitamins B, C, essential oil, pectin, guvertin and mineral salts. The vitamin C content is damaged during cooking, so it can be consumed raw to prevent colds and infections. Its flavonoids play an important role in strengthening the immune system

Garlic (*Allium sativum* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Monocots
Order:	Asparagales
Family:	Amaryllidaceae
Subfamily:	Allioideae
Genus:	*Allium*
Subgenus:	*A.* subg. *Allium*
Species:	***A. sativum***

Its genetic center is Central Asia, but it is a popular plant all over the world. Due to its taste and healing effects, its cultivation has been widespread in Hungary since the 15th century. Makó and its surroundings are center to the cultivation of Hungarian garlic.

It is a perennial, herbaceous, short-day plant. However, its light requirement increases continuously during its development.

Root

Develop a fibrous root system.

Garlic

Garlic consists of 8-10 bulbs. These develop from lateral buds that form the base of the garlic leaf.

Flower

A spherical umbel inflorescence consisting of many small flowers.

Cultivability

Garlic can be propagated vegetatively from bulbs. It can only be grown in the field. It is planted in early spring or mid-October. Plant spacing is 8-10 cm, row spacing is 30 cm, planting depth is 5-8 cm, 10 dkg/m^2 of bulbs.

Cultivation requirements

- growing temperature 19 ± 7 °C ; germination temperature 4-6 °C,
- loose structure, rapidly warming, humus or brawn sandy soil,
- 200-300 mm water (during the total growing),
- 70-80% air humidity,
- medium light requirements, but prefers long daylight hours during its development,
- nutrient: 3.8 kg N; 1.2 kg P_2O_5, and 4.2 kg K_2O for 1000 kg yield.
- magnesium sulfate supplement.

Harvesting

Garlic is picked by machine, in smaller plots by hand (with a loosening spade). After harvesting, it is dried. Care must be taken to avoid mechanical damage to the garlic heads, as this greatly affects storability. After drying, 1 kg of garlic contains 30-32 heads. It is an early-maturing vegetable crop, so it can be easily incorporated into the crop rotation, for example, as a pre-crop for overwintering lettuce, beetroot, spinach. The traditional cultivation and storage of garlic became widespread in Makó and its region in the last century.

Plant protection

Burkholderia cepacia,

Fusarium oxysporum,

Botrytis allii,

Peronospora destructor,

Ditylencus dipsaci,

Delia antiqua,

Napomyza gymnostoma,

Suillia univittata,

Acrolepia assectella

Effect on human body

Garlic contains sulfur-containing essential oil, vitamin A, B, C, E. Garlic has digestive, intestinal disinfectant, deworming, blood pressure lowering, and bile and liver function enhancing effects. It reduces the risk of developing coronary artery disease.

Cabbage (*Brassica oleracea* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Brassicales
Family:	Brassicaceae
Genus:	*Brassica*
Species:	***B. oleracea***

Vegetable plants belonging to the Brassicaceae family originate from the Mediterranean region. Their common ancestor is wild mustard. As a result of breeding work, they can also be grown safely in the temperate zone. In Hungary, regional varieties have been developed in the Hajdúság region, Vecsés and Szentes regions.

It is a biennial, long-day, herbaceous plant.

Root

It has a spindle-type taproot, on which root branches develop. Its root system spreads far and wide in the soil.

Stem

Develops in the second year, can grow to 1-1.5 m tall. The inflorescence and the fruit (seed stalk) develop on this.

Flower

Yellow colored, cruciform flowers. It develops from second year.

Leaf

The stem-leaves are bluish green or red (red cabbage). The surface is ashy, the edges are wavy, lacy or ruffled.

Fruit

It contains small, black, spherical seeds. It retains its germination capacity until 3 years.

Cultivability

Cabbage and brassicas are propagated from seedlings or seed. The seedlings are grown in 5x5 cm nutrient cubes. It can be cultivated in the field as a main or secondary crop. Short-maturing varieties are planted at a distance of 40x30 cm, medium-maturing varieties at a distance of 40x50 cm, and late varieties at a distance of 50x60 cm. Expected yield is 3-4 kg/head of cabbage. Cabbage and brassicas require soaking when planted in early spring.

Table 6. Propagation of cabbage

	Sownig	Planting	Harvest
Short growing season	II.10-III. 25 V.-VI .5	III. 15- IV. 25. VI. 20- VII. 10.	VI. 5- VI. 25. VII.- IX. 25.
Medium growing season	III. 15. V. 15	IV. 10- IV. 20. VI. 15 – VI. 25	VII. IX.
Long growing season	III. 15- IV. 10.	IV. 15- V. 30.	IX. 30- X. 30.

Cultivation requirements

- sandy soil with neutral pH or loose loess soils,
- less heat-requiring (Markov-Haev 13± 7 °C), germination temperature 5 °C,
- organic fertilizer requirement 30-40t/ha, N: 3.5 kg P2O5: 1.3 kg K2O: 4.3 kg for 1000 kg of yield,
- very water-intensive, irrigation equipment is required during cultivation,
- requires regular plant care: weeding, irrigation, nutrient solution application, max. EC 1.5,
- plant protection, good predecessor crops are cereals and legumes.

Plant protection

Rhizoctonia solani,

Plasmodiophora brassicae,

Peronospora parasitica,

Erysiphe cruciferarum,

Delia radicum,

Phyllotreta spp.,

Mamestra brassicae,

Gastropoda spp.

Effect on human body

Cruciferous vegetables are very nutritious. They are mainly high in vitamins A, B, K and C, low in calories, high in fibre and contain anti-tumor substances such as 3,3′ diindolymethane, sulforaphane and selenium. Brassicas are very good sources of iron, potassium and calcium. Vecsés sauerkraut has a detoxifying and digestive stimulating effect, as it promotes the growth of beneficial bacteria in the intestines. Cabbage produces S-methyl-methionine, which protects the stomach lining from the corrosive effects of stomach acid.

Carrot (*Daucus carota* L. *subsp. sativus*)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Apiales
Family:	Apiaceae
Genus:	*Daucus*
Species:	*D. carota*
Subspecies:	***D. c.* subsp. *sativus***

Its genetic center is Asia, although its cultivation was most widespread in the Roman Empire. In the 17th century, it was still cultivated in white, yellow and purple colors and the orange carrot was bred by Dutch gardeners.

It is a biennial, herbaceous, short-day plant.

Root

Strong, storage taproot, its shape can be elongated, blunt, or round. It develops in the first year. In its cross section, the lighter bark part and the woody part, the "carrot heart", can be clearly distinguished.

Stem

The 20-25 cm tall stem develops from the carrot body. It develops a seed stem only in the second year

Leaf

The carrot develops rosettes leaves, which is rich in essential oils.

Flower

Umbrella form, insect-pollinated. When growing from seed, there is a risk of infection with wild mustard, therefore it can only be grown by maintaining isolation distances and using adequate weed control.

Seed

Achene crop. It has tiny seeds, which are rich in essential oils. When sowing, the seeds are coated with a plant protection product or nutrient dragee for better seeding. Its seeds retain their germination capacity 3-4 years.

Cultivability

It is mostly grown on arable land, but it can also be used for early transplanting in unheated cultivation equipment. Due to its relatively short growing period and low temperature requirements, it can be used as a pre- and post-crop. Soil boredom can develop quickly in monoculture, so its crop rotation is 3-4 years. Sowing depth is 2-3 cm, 40 cm row spacing and 4 cm plant spacing. Seed requirement is 3-4 kg/ha. Since its phenological phase is two years, we distinguish between the first-year commercial beet cultivation and cutting cultivation, and the second-year seed cultivation period.

Carrots can be classified into the following variety groups based on their growing season:

• short growing season (80-100 days),
• medium growing season (120-180 days),
• long growing season (220 days).

Growing requirements

- loose, deeply tilled, calcareous, sandy soils, less heat-requiring
- (Markov-Haev 16± 7 ºC), germination temperature 3-4 ºC,
- moderately water-requiring, cannot be grown in stagnant water areas, only requires irrigation during periods of low rainfall,
- does not require direct organic fertilization,
- its potassium requirement stands out among other nutrients,
  N: 4.3 kg P_2O_5: 1.8 kg K_2O: 6 kg for 1000 kg carrot,
- requires regular weeding, plant protection, and adjustment of the number of stalks.

Harvesting

Depending on the growing season, the beet is harvested with a beet lifting plow, a beet harvester, or a plow equipped with a curved ploughshare. After harvesting, it is sorted and then stored in a cellar or prism. The beet is always stored in a ventilated, airy place, as this is when the most fungal diseases can develop. The average yield is 15-25 t/ha, depending on the variety and growing season. With irrigation, double amount be harvested.

plant protection

Sclerotinia sclerotiorum,

Erysiphe heraclei,

Botrytis cinerea,

Rhizochtonia carotae, solani, crocorum,

Alternaris porri,

Agriotes larva,

Aphis fabae,

Meloidegyne spp.

Effect on human body

Low levels of ß-carotene in the blood increase the risk of cancer. The body converts ß-carotene into vitamin A, which strengthens the vision mechanism. Its deficiency leads to night blindness. In this case, the eye cannot adapt to low light. Carrots are recommended to be eaten raw, as this way the body can utilize the nutrients in the carrot better. However, you should pay attention to the level of nitrates and pesticide residues. It should be zero, if possible. The apiol content of parsley enhances the functioning of the gastrointestinal tract, and its tea is also consumed in case of cystitis. **Parsley??** can be recommended for preventing the formation of kidney stones and kidney sand. The great value of celery is its high organic sodium content, but it also contains calcium, phosphorus, iron, magnesium, potassium and some trace elements. Its leaves also contain essential oils (limonene, selenene, alkyl phthalides), furocoumarins and flavonoi

Parsley (*Petroselinum crispum* Mill.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Apiales
Family:	Apiaceae
Genus:	*Petroselinum*
Species:	***P. crispum***

Its genetic center is the Eastern Mediterranean region, and it has been used for centuries as a seasoning and medicinal herb. As a result of breeding work, two varieties have emerged.

It is a biennial, herbaceous, short-day plant.

Root parsley (*Petroselinum crispum convar. tuberosum*),
a root vegetable of which both parts – the root body and the foliage – are used. It is widely grown in both arable land and field cultivation.

Leaf parsley (*Pertoselinum crispum convar. foliosum*),
a vegetable that cannot develop edible roots, so only its foliage is used. Its leaves contain numerous microelements and vitamins, so it is often used in Hungarian gastronomy. However, its cultivation is not very widespread in our country.

Growing and propagating parsley

Parsley can be propagated by sowing seeds and planting undersized roots. Sowing can be done at the end of February, mid-July and in the winter months. It is advisable to cover the soil with black film to facilitate warming, preserve the soil's water content and suppress weed growth. During these periods, parsley can also be grown in low-frame (18 cm) film tunnels with small air spaces. The undersized roots are planted at a row spacing of 20 cm and a plant spacing of 3-5 cm, making sure that the growing tip is above the soil surface. Planting can be done in September and/or March. At the end of the growing season, they are picked, cleaned and then knotted into ten bundles. Average yield 200 kg/m^2. Based on the size of the root body, we are talking about long and semi-long parsley. The ecological requirements, growing season, and plant protection of parsley are largely the same as those of carrots.

Growing requirements

- Loose, deeply tilled, calcareous, sandy soils, less heat-requiring
- (Markov-Haev 16± 7 ºC), germination temperature 3-4 ºC,
- moderately water-requiring, cannot be grown in stagnant water areas, only requires irrigation during periods of low rainfall,
- does not require direct organic fertilization, -
- its potassium requirement stands out among other nutrients, N: 4.3 kg P_2O_5: 1.8 kg K_2O: 6 kg for 1000 kg parsley,
- requires weeding, regular weeding, plant protection, and adjustment of the number of stalks.

Celery (*Apium graveolens* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Apiales
Family:	Apiaceae
Genus:	*Apium*
Species:	***A. graveolens***

Its genetic center is the Mediterranean coast, although its wild form can be found in the swampy areas of Asia. Both the tuber and foliage of the domesticated celery can be used, and its alkaloids and essential oil composition give celery a characteristic taste and aroma. There are 3 known varieties of celery. The tuberous, the pale and the chive celery.

It is a biennial, herbaceous, short-day plant.

Root

It is a taproot system, but this is only visible at a young age. In the case of celery, we are talking about a tuber, which is divided into 3 parts. From the stem below and above the rhizome, and from the upper part of the taproot. The pale and the chive celery are not able to develop tubers, in their case the taproot can be observed.

Leaf

Rich in essential oils, uniquely fanned needles.

Stem

80-120 cm tall, ribbed, rough-surfaced herbaceous stem. Develops in the second year (seedstem).

Flower

A compound umbel inflorescence formed by unisexual flowers. The flowers have two pistils but their stamens open first, so the flowers are self-sterile. Consequently, they are cross-pollinated.

Seed

Achene crop. The seeds, rich in essential oils and other alkaloids, develop in this. They retain their germination capacity for 3-4 years.

Cultivability

Celery does not have high heat requirement, so it is safe to grow in the field or to plant under cold foil. It is particularly sensitive to the salt content of the soil, so it produces excellent quality tubers best on neutral soils well prepared with organic fertilizer. We mostly propagate it from seedlings, as the tiny size of the seeds does not allow for re-sowing. The seedlings are planted at the age of 12 weeks, with 6 leaves, at a row spacing of 30 cm and a plant spacing of 10 cm. Its cultivation technology is well mechanized on large-scale farms. Autumn-harvested tuberous celery provides 30-40 t/ha of harvestable tubers. It can be easily incorporated into crop rotation.

Cultivation requirements

- Medium-dense, potassium-supplying, brown sand, possibly loamy soils,
- less heat-requiring (Makov-Haev 19± 7 °C), germination temperature 5-6 °C,
- water-needs plant, requires regular irrigation during cultivation, max. EC 1,
- potassium requirement is outstanding among other nutrients,
- sensitive to boron deficiency, 20-30 t/ha organic fertilizer, N: 6.5 kg P_2O_5: 2.5 kg K_2O: 8 kg for 1000 kg celery,
- requires potassium top dressing in the middle of the growing season.

Celery varieties are classified into two groups based on their growing season:

• short growing season varieties: 180-220 days,

• long growing season varieties: 210-240 days.

Plant protection

Phoma apiicola,

Septoria apii,

Melolonthidae,

Meloidogyne spp.

Lettuce (*Lactuca sativa* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Asterales
Family:	Asteraceae
Tribe:	Cichorieae
Genus:	*Lactuca*
Species:	***L. sativa***

Its genetic center can be found on the Mediterranean coast, where it was consumed in ancient times. It was a vegetable plant introduced to our country for field cultivation in the 16th century, and its intensive cultivation was boosted by the spread of plastic film tents. It was primarily cultivated in the sunny southern parts of the Great Plain (Szentes, Szeged), and then its intensive cultivation area developed around Budapest.

It is an annual, but can also be grown over winter, long-day, herbaceous plant.

Root

It has a spindle-type main root, from which thin lateral roots branch.

Stem

Under optimal conditions, the seed-stem develops only in the second year. This is where the inflorescence and the fruit (seed-stem) develop.

Flower

Nest form. Polygamous, monoecious, self-fertile.

Leaf

Yellow-green, thin, tightly closed leaves. Their surface is smooth or blistered. Their edges are entire or wavy.

Seed

Achene crop, in which its small, elongated, silvery seeds develop. They retain their germination capacity for 3-4 years

Cultivability

It is the shortest-growing-season vegetable, so it can be extremely flexibly included in the crop rotation. It can be grown in arable land from early spring to late autumn. There are also overwintering varieties. It does not require intensive heating when sprouting. In high heat it sprouts into a seed stalk without forming a head. It is propagated from coated seeds or seedlings. 800 seedlings can be grown from 1g of seed. In arable land, it is planted with a row spacing of 40 cm and a plant spacing of 30 cm. In a growing system, it is planted in a 25x25 cm bond.

Cultivation requirements

- Loose, easily warming, salt-free soils, less heat-requiring,
- cold-resistant plant (Markov-Haev 16± 7 °C), germination temperature 2-4 °C, above 20 °C
- it sprouts into a seed stalk, long-day, therefore it requires supplementary lighting during winter germination,
- water-intensive, its water requirement is 3-4 irrigations/growing season, max. EC 1.5,
- organic fertilizer requirement 40 t/ha, if necessary we can also apply artificial fertilizer, N: 4 kg P_2O_5: 1.8 kg K_2O: 5 kg for 1000 kg of yield,
- plant care focuses on weeding and plant protection.

Lettuce is usually grown in a plastic tent, as growing it in a greenhouse is not profitable. The main growing periods are:

- winter growing,
- early spring growing,
- late spring growing,
- autumn growing.

Table 7. Growing seasons of lettuce

	Sowing	Transplanting	Harvest
early spring growing	XII.	II.	IV.
early spring growing	I.	III.	IV.
summer growing	III.	-	V.
autumn growing	VII.	VIII.	IX.
autumn growing	VIII.	IX.	XI.
winter growing	X.	XI.	II.

The phenological phases of lettuce

Germination, emergence, cotyledonous seedling, rosette formation, heading, seed stalk formation, flowering, seed ripening. The growing period of lettuce depends on the time of sowing, temperature, light conditions, cultivation methods, correct nutrient supply and plant protection. Depending on this, we speak of varieties with a short: 50-day, medium: 50-60-day, and long: 70-day growing period. This period may be shortened during intensive cultivation.

Intensive growing of lettuce

Intensive cultivation is fundamentally based on profit orientation. The successive change of crops greatly depletes the soil, therefore the supply of nutrients into the soil must also be intensive. However, intensive cultivation can also degrade the soil structure, therefore the use of organic fertilization is inevitable in order to preserve the soil fertility. However, such problems cannot arise in soilless cultivation. The average yield, its timeliness and harvestability can be calculated precisely. Among the liquid-based cultivation systems, tank culture offers the possibility of intensive cultivation of lettuce, rapid change of crops, excluding problems related to soil boredom, soil structure deterioration, and maintaining soil fertility. In this system, there is no solid fixing medium between the root and the nutrient solution. The tank culture system is not an intensive lettuce growing solution in Hungary, but is very common in the Netherlands. During the winter months, the intensity of natural light decreases significantly, so the closure of the leaves and the formation of lettuce heads take longer.

Plant protection

Lettuce Mosaic Virus,

Pseudomonas marginalis,

Bremia lactucae,

Marssonia panattoniana.

Pemphigus bursarius,

Helicoverpa armigera,

Aphidoidea spp.,

Thrips tabaci,

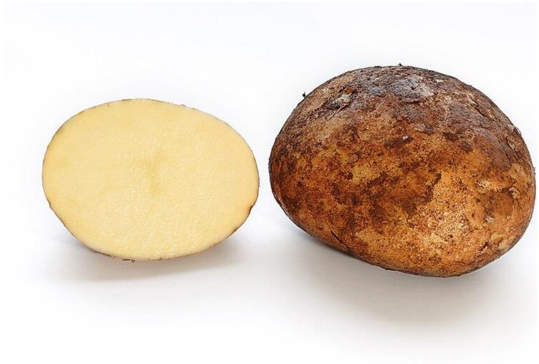
Agriotes spp.

Effect on humad body

An easily digestible vegetable. Due to its high vitamin C, B1, B2, B6, $CaCO_3$ and low protein content, it can be easily included in our daily diet. It contains large amounts of calcium, potassium, phosphorus and iron, so it can also be consumed by diabetics and overweight people. The body can ideally use the calcium content of lettuce for bone formation. Its flavoring substances have a good effect on the functioning of the stomach. The dark green outer leaves contain significantly more ß-carotene than the light green inner leaves. It is low in energy, so it can be easily included in a diet. However, you should pay attention to the amount of nitrate and pesticide residues that may be present.

Early Potato (*Solanum tuberosum* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Asterids
Order:	Solanales
Family:	Solanaceae
Genus:	*Solanum*
Species:	***S. tuberosum***



Its gene center is Chile and Peru. It was introduced in Europe in the 15th century. After cereals, it is the most important food plant. Its distribution and use are well known throughout the world. It can also be grown in Hungary, although the yield of domestic varieties was not competitive during the Cold War, so more emphasis had to be placed on domestic potato breeding and production technologies. By the end of the 1960s, the new Dutch seed potatoes had completely replaced domestic varieties. In our country, the demand for early potato seedlings was growing. Balástya and its surroundings became the home of intensive potato cultivation.

Annual, herbaceous, long-day plant.

Tuber

A thickened underground stem structure that develops from the stolons. Its function is to store nutrients.

Root

They are located in the top 30-35 cm of the soil and are responsible for absorbing nutrients.

Stem

The stem is hollow stalk, herbaceous, it has main and side branches. Its hollow inside and its length is 40-120 cm, depending on the variety.

Flower

Umbrella inflorescence. Variegated, monoecious, self-fertile.

Fruit

A berry crop with many seeds. It is poisonous!!!

Cultivability

Early Potatoes can be grown in open fields and can also be grown in unheated, small air-filled foil tents. (It was first used in 1960 in Balástya by small-scale farmer József Csányi). On the easily warming, brown sandy soils of the Great Plain, it is excellent for early sprouting. Potatoes are sprouted from tubers. Pre-germination is a procedure that can be used before sowing for better development. Pre-germination lasts 4 weeks, under somewhat poor light conditions. The amount of seed potatoes can be increased by cutting the tubers, although development is slightly more uncertain at this time due to the stress caused by slicing. In rare cases, early potato sprouting is also done from potted seedlings.

Growing requirements

- easily warming, humus-rich, brown sandy soils, possibly loamy soils,
- potassium requirement is outstanding among other nutrients,
- heat-requiring, 20-25 °C during the day, 12 °C at night,
- very sensitive to frost,
- water requirement increases during intensive tuber development (250 mm), requires irrigation, max. EC 1.5,
- light requirement increases during the flowering period, later this becomes less and less,
- organic fertilizer requirement 10 kg/m^2, potassium requirement is outstanding among other elements, N: 5.9 kg P_2O_5: 2.2 kg K_2O: 8.0 kg for 1000 kg tubers,
- requires regular weeding and hoeing.

Potato Mosaic Virus,

Phytophthora infestans,

Synchytrium endobioticum,

Fusarium avenaceum,

Alternaria alternata,

Agriotes spp.,

Leptinotarsa decemlineata,

Aulacorthum solani,

Melolonthidea.

Radish (*Raphanus sativus* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Brassicales
Family:	Brassicaceae
Genus:	*Raphanus*
Species:	***R. sativus***

Its genetic center is Asia, more precisely China. It was brought to Europe by Marco Polo in the 13th century. It is a very widespread vegetable in our country, and its cultivation area was established in the Great Plain. During its breeding, 3 groups were formed: the monthly, the summer, and the autumn-winter garden radish.

An annual, herbaceous, long-day plant.

Root

In the case of the month-old radish, it is the tuber, which is formed from the hypocotyl. In the case of the other two varieties, it is the root tuber.

Stem

80-100 cm tall, herbaceous, the one-month radish develops a seed stalk in the same year, the other two varieties in the second year.

Leaf

It is attached to the stem tuber by a petiole. It is divided into lobes, its surface is slightly hairy, its edge is smooth or wavy.

Flower

Leafless racemose inflorescence, formed by cruciferous flowers. These are white, bisexual, monoecious, self-sterile or foreign-pollinating flowers.

Seed

Round shaped. Their germination capacity 4-5 years.

Cultivability

Radish is mostly grown in pots, but it can also be grown outdoors. Its seed size allows for direct sowing. Sow in 5x5, 8x8, 12x12 cm rows, 2 cm deep. Japanese icicle radish requires a deeper seedbed. Due to its low heat requirements, it can be sown in early spring and late autumn, and does not require heated equipment.

Cultivation requirements

- a plant with medium nutrient requirements that can be grown on most soils,
- but is sensitive to Cl--,
- its heat requirements are low (Markov-Haev 13 ± 7 °C), germination temperature is 2 °C,
- its water requirements are high during seed germination (60%), then gradually decrease,

- its nutrient requirements are medium, N: 5 kg P_2O_5: 2 kg K_2O: 5 kg for 1000 kg of crop,
- its weeding can only be done mechanically, thinning is advisable, a good pre- and follow-on crop, can be easily incorporated into crop rotation.

Table 8. Cultivation period of radish

Sowing	Harvest
January	II.28-III.25.
February	III.15-IV.1.
March	IV.1-IV.30.
April	IV.30-V.11.
September	X.15-XI.15.
October	XI.15-XII.15.
November	I. 1-I.30.
December	II.1-II.28.

Plant protection

Radisch Mosaic Comovirus,

Albugo candida,

Peronospora brassicae,

Phyllotreta spp.,

Elateridae spp.

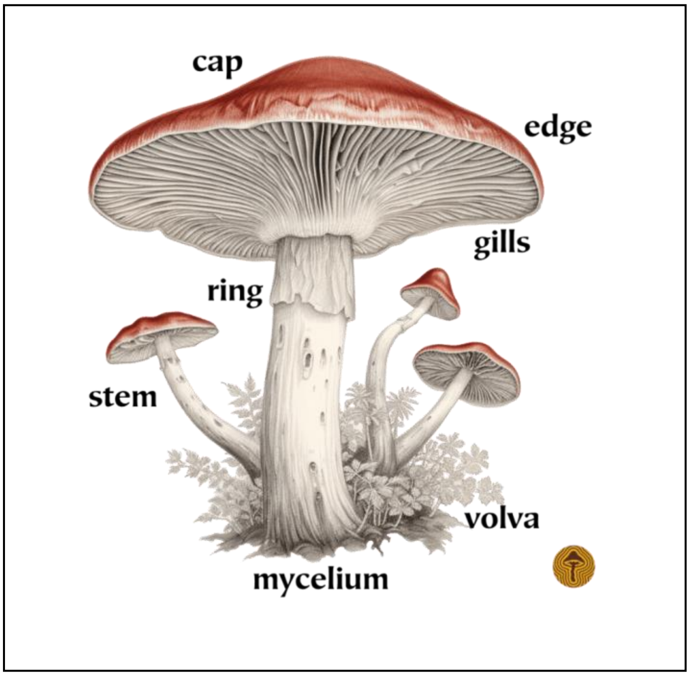
Effect on human body

Its essential oils contain many sulfur-containing compounds, and its pungent taste and a significant part of its medicinal properties are due to its sulfur-containing mustard oil glycosides and sulfur-containing essential oil. By stimulating bile production, it promotes and regulates digestion and thus metabolism. It helps break down fats, is an excellent appetite stimulant, and since it eliminates bile stasis, it also helps prevent bile diseases, including gallstones (however, its use is not recommended in cases of already formed gallstones). Its carotene value is low. It is used in natural medicine as a diuretic.

Mushroom (*Agaricus bisporus* L.)

Kingdom: Fungi
Division: Basidiomycota

The name mushroom includes more than 70 Central European species belonging to the genus (Agaricus). Most of these are among our best edible mushrooms, only the group of species collectively known as the yellow champignon are poisonous. The edible species are characterized by a pleasant mushroom smell, the so-called "anise smell", while the poisonous yellow champignons have a strong carbolic smell, reminiscent of ink. This disgusting smell only intensifies with cooking, and can cause severe stomach upset, especially in people with weaker stomachs. Around 1900, the French Pasteur Institute succeeded in producing the mushroom's propagation material under sterile conditions. This is when the period of classical cultivation begins, which lasts until about 1950. During this time, the technology of composting was continuously refined, cultivation was carried out exclusively on horse manure, and the achievable yield was around 3–5 kg. The cultivation of Pleurotus on trees also began during this period.



Basidiomycetes are organisms without chlorophyll and do not photosynthesize. Their fruiting bodies contain valuable proteins for our bodies. They have no roots, and their bodies are built up and supplied with nutrients by fungal filaments (hyphae). The filaments are compacted into a mycelium, which builds up the fruiting body. The fruiting body is the edible part of the mushroom. The fruiting body forms a very fleshy cap (pileus), with thin plates (lamella) at the base of the cap. The fruiting body is surrounded by a collar-like formation (sterigma).

Development of the champignon

- development of germs (production of reproductive cells, spores),
- development of the fruiting body (formation of the stem and cap).

The process of growing champignons

Compost preparation

This is the medium in which the sprouts develop, and this nutrient medium ensures that the basidium fruiting body can absorb micro- and macro-elements. Its is made exclusively from natural materials, straw or corn stalks, various plant wastes, enrichment materials (soybean meal), organic manure (horse, poultry) and gypsum ($CaSO_4$) in the appropriate ratio. pH 7.

Germ
(propagation material) inoculation. Barley, rye or wheat grains inoculated with mycelium produced under sterile conditions.

Mulch covering
The mulch protects against drying out and temperature fluctuations, we water the sprouts through it, thereby ensuring the moisture content of the compost. It is also a support medium that protects the fungus from decay. Its material is disinfected peat.

Determination of a growing area
Cellars, limestone caves, mine shafts, and mushroom growing houses and tents designed for this purpose can serve as suitable facilities for growing champignons.

In the first step, the compost material is filled into polyethylene bags (20 kg). The bags are placed in the growing room on one or three-level shelves in a grid arrangement of 5 bags/m2. The humidity of the room can be maintained at a high level by sprinkling the floor. This is followed by the weaving phase. The sprouts must be woven in at the temperature specified by the manufacturer, as temperature fluctuations damage the mycelium. For optimal germination, 25-27 °C is required, along with 95% humidity. Covering is done 10-12 days after the germination, with pre-moistened peat, which protects the mushrooms from drying out. The covering material is spread evenly, 5-6 cm thick. After the covering material is applied, the plant protection agents must be sprayed. During the incubation period (20 days), in addition to watering, ventilation, and ensuring humidity, the "stirring" process is carried out, which separates the mycelium, thus making the mushroom fruiting bodies the same size. Sprouts appear 14 days after covering, and then mushrooms ripe for picking a week later. The mushrooms ripen in stages, grouped in bunches.

Cultivation of edible mushrooms can only be carried out in rooms with high humidity (85-95%), well-ventilated, and dark. Its cultivation is divided into 3 stages:

- transplantation stage,
- latency stage, fruiting stage.

After the cultivation is completed, the compost - due to its high nutrient content - can be used for any vegetable crop.

Its growing requirements

Its heat requirements vary, depending on the cultivation process, from 30 °C to 16 °C, it has no light requirements at any stage of cultivation, its nutrient requirements are provided by compost during the growing period, it requires irrigation through the covering material, intensive air exchange should only be ensured at the end of the growing period.

Mushroom protection

Pseudomonas tolaasii,

Verticillium fungicola,

Mycogone perniciosa,

Coprinus spp.

Lycoriella spp.,

Ditylenchus mycelophagus,

Tyrophagus spp.

Effect on human body

The mushroom body is rich in valuable digestible proteins, but at the same time a low-calorie diet. The selenium content of the champignon mushroom can not to be neglected either, which basically plays an antioxidant role and usually participates in the body's metabolism together with tocopherols. The glutathione peroxidase enzyme contains selenium and catalyzes the peroxide decomposition reaction, thereby protecting cell membranes from oxidative damage, preserving the integrity of unsaturated lipids and cell membranes. The dangerous mercury content of the collected mushrooms has increased greatly in recent years, so we must buy from a verified place only!

Chapter 7

Fruit production

Of the fruits grown in temperate climates, 20 species can be grown well in Hungary. Traditional fruit growing areas have developed in our country, similar to the cultivation of vegetable crops. The largest growing regions are the Southern Great Plain and Dunántúl. Fruits are essential nutrients for the human body due to their sugar, vitamins, minerals and organic acid content. Traditional fruit growing also requires a high level of horticultural knowledge. Intensive fruit production is carried out in an organized manner and under constant supervision. They emphasize the biological characteristics of the plant. Growers select the area's most favorable for growing a given fruit, ensuring the most favorable conditions.

Fruit trees taxonomy

For horticulture, the most important taxonomic unit is the species, within the species the variety, and the smaller units derived from the variety. According to international nomenclatures, cultivated species are classified by double Latin names: E.g.: *Malus domestica* Borkh

Varieties are developed from the breeding of the species, e.g. Jonathan, Starking, Delicious, etc. Varieties may have different color variations, which must be listed separately. E.g.: Golden deliciouse, Red deliciouse.

Table 1. Botanical classification

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Malus*
Species:	***M. domestica***

If two varieties are crossed during breeding, the offspring is called a hybrid. From a species vegetatively propagated, for example by budding, is called a clone. The clones are named after a series of letters and numbers. For example: Jonathan M 40.

Fruits form morphological groups based on their external appearance. These groups are called taxonomic units! Fruit-bearing plants are classified into botanical systems based on their flowers and fruit-forming characteristics. Based on the similarity of their products, they form a so-called economic or practical system.

Pome	**Rosaceae**
- apple	*Malus domestica* Bork.
- pear	*Pirus domestica* L.
- quince	*Sidonia oblonga* Mill.
- medlar	*Mespilus germanica* L.
Drupe	
- cherry	*Cerasus avium* L.
- sour cherry	*Prunus cerasus* L.
- plum	*Prunus domestica* L.
- peach	*Persica vulgaris* L.
- apricot	*Prunus armeniaca* L.
- almond	*Amigdalus communis* L.
Nuts	**Juglandaceae**
- walnut	*Juglans regia* L.
Achene	**Rosaceae**
- strawberry	*Fragaria* x *ananassa* Duch.

Chapter 8

Morfology of fruit-bearing plants

Fruit-bearing plants can develop normally:

- tree,
- bush,
- shrub,
- subshrub,
- herbaceous.

The structure and morphology of the fruit tree:

Fruit trees have a taproot system, their above-ground part consists of the trunk and the crown. The crown is usually built on the crown (central axis), from which the perennial branches develop, from the branches the 2-4-year-old fruiting branches, the 1-year-old canes, as well as the annually renewed leaves, flowers, shoots and fruit. They are usually long-lived plants**.**

The structure and morphology of fruit bushes

The root system of fruit bushes penetrates shallowly into the soil, but at the same time covers a large area. They usually have a lateral root system. Their above-ground part is characterized by a crown as a central axis and the lack of perennial branches. Of course, quince, medlar and hazelnut can also be grown into a trunk using pruning methods. Fruit bushes are characterized by the fact that they branch immediately above the ground and always renew themselves from below. Their fruiting parts are the same as those of trees. They are also characterized by their long-term fruiting capacity.

Structure and morphology of fruit shrubs

Their root system is an adventitious root system, which is shallowly rooted in the soil. The characteristic feature of the root system is the shrub trunk, from which the plant regenerates. The structure of their above-ground part is similar to that of bushes, but of course, all of them can be grown into a trunk-like tree by grafting onto a golden currant rootstock. Red and black currants, as well as gooseberries, are classified as fruit shrubs.

Structure and morphology of fruit-bearing semi-shrubs

This group includes raspberries (*Ribes iadeaus*) and blackberries (*Ribes ceasius*). Their root system is an adventitious root system, with the characteristic that adventitious buds develop on these adventitious roots, and then root shoots from them. Their above-ground parts consist of the 1st-year non-fruiting shoot, the 2nd-year fruiting shoot, and the fruited shoots. The fruiting shoots dry up in the year of maturation and must be removed. The above-ground part of the fruiting shoot usually has two replacement buds, from which the main shoots develop.

The structure and morphology of the herbaceous fruit-bearing plant

Strawberries belong to this group. The root system of strawberries grown from seeds penetrates the soil to a depth of about 20 cm. However, the root system of strawberries grown from suckers is shallower. The above-ground part consists of leaves, fruiting and suckers, and suckers. For propagation, seedlings grown from suckers are used.

Fruiting parts of fruit-bearing plants

Fruiting parts of apple trees

The fruiting parts of the plants belonging to the apple tree practical system are the same as those of the apple and pear, as well as the quince and medlar.

- **Short fruiting parts**

Spear:

0.5-5 cm long cane, on the side of which there are no buds, only the petiole of the leaf rosette. These are called leaf axils. A well-developed mixed bud can be found at the end of the spear. The flowers appear at the end of the shoot developing from the mixed bud. In apples, the middle flower of the inflorescence opens first, and in pears, the outer flowers open first. During fruit setting, the shoot that bears the fruit thickens, and on the sides there are shoot buds, from which shoots develop. Because of this phenomenon, the bud is called a mixed bud. The length of the shoots can be controlled by pruning.

Short fruiting spike

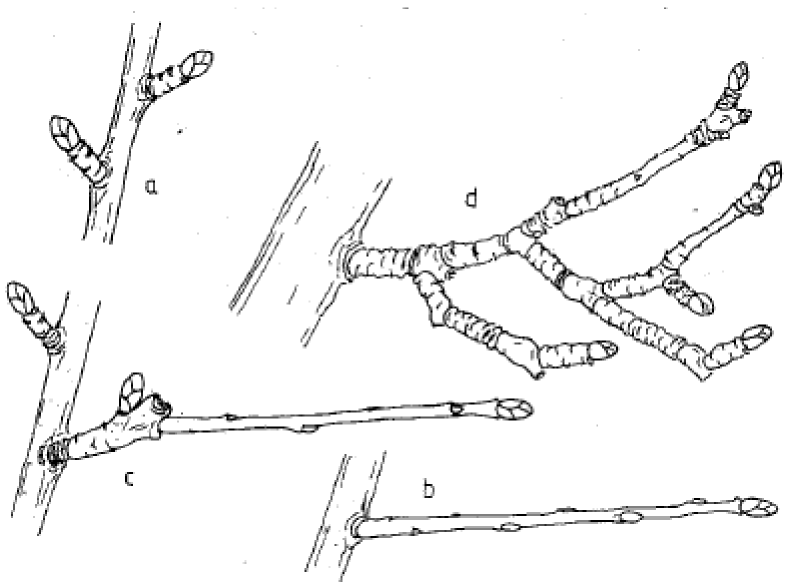
5-20 cm long cane with immature shoot buds on its sides and well-developed mixed buds at its tip. The immature shoot buds usually form spears.

Fruiting body

A fruiting body developing from mixed buds, on which spears, short fruiting spike, and shoots of various lengths develop.

Fruiting branch

A multi-branched fruiting body. After 4-5 years it usually develops smaller mixed buds, so it is advisable to remove them.



a - spear

b - short fruiting spike

c – fruiting body

d – fruiting branch

Figure 1. Fruiting parts of apple trees

Fruiting parts of drupe fruits

Drupe fruits produce their fruit buds on the one-year-old part of the tree, the shoot, and therefore do not actually have older fruiting parts. The exceptions are the characteristic fruiting parts of the bushy fruiting tree, the cherry, and the sour cherry.

- **Short fruiting parts**

Fruiting buds

A short fruiting part with buds at its tip. The middle one is the shoot bud, and the others are the flower buds. A fruiting stem with a smaller number of flower buds also occurs on almonds and peaches, but shoot buds do not always develop in these. Therefore, they usually dry up after the fruit ripens. The flower buds of a 4-5-year-old bushy fruiting stem are less developed, so they must be removed.

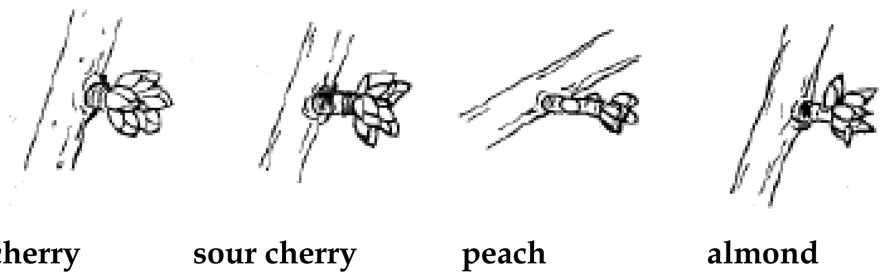


Figure 2. Fruiting parts of drupe trees

Walnut fruiting parts

The walnut grows three types of buds, in this it is the same as the hazelnut. Both plants develop shoot, axillary and mixed buds. The mixed bud develops at the tip of the short shoots, below which are the axillary and shoot buds. The buds bearing stamen flowers (axillary) are located on the sides of the shoots, in the axils of the axils caused by the previous year's petioles. The mixed bud always develops a short shoot, at the top of which the fruit inflorescence of the walnut develops. Different buds are formed on the sides of the shoot. Some walnut varieties can develop mixed buds not only at the tip of the shoots, but also on the sides. These are the types of leathery fruiting varieties.

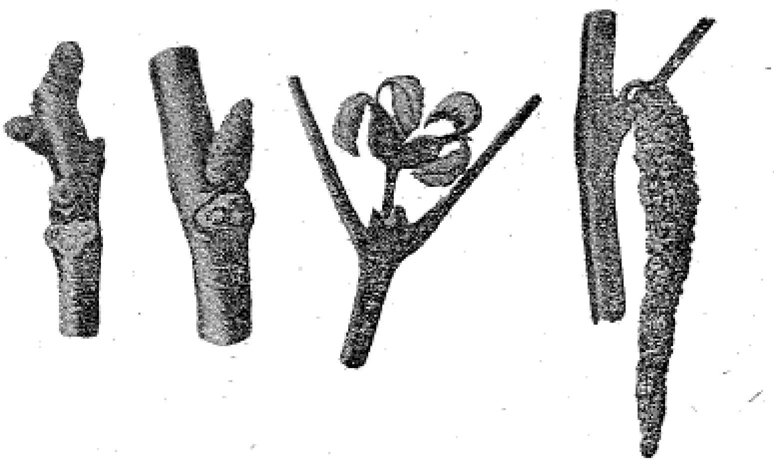


Figure 3. Fruiting parts of walnut

Chapter 9

Life stages of fruit plants

Growth stage

The stage lasts from planting to fruiting. The development of the vegetative parts is vigorous, the root system, trunk, crown and the vegetative parts on it are formed. In this stage, flower bud differentiation occurs, but the fruit tree does not yet bear fruit.

Fruiting period

The development of the vegetative parts slows down slightly, but at the same time the generative character strengthens. The amount of fruit formed on the crown is increasing, but it does not yet reach the amount characteristic of the species and variety.

Fruit balance stage

The fruit yield of the crown is continuous and balanced from year to year. The amount of fruit is characteristic of the species and variety.

Period of declining yield

The crown still bears fruit, but the quantity of the fruit is no longer sufficient. The fruiting part begins to die in some parts of the crown. These parts are rejuvenated (in small gardens), or the plantation is replanted (in intensive farming).

The annual biological cycle of fruit-bearing plants

The annual biological cycle refers to the annual vegetation and dormancy periods. This period is monitored from spring to spring and biological changes are determined.

Vegetation period

The first change begins in the underground parts with the activation of root functions. Budding begins on the crown within 20-25 days at an average daily temperature of 8-10 °C. The flowering period lasts from the end of February to mid-April, depending on the species. After flowering, the development and ripening of the fruits closes this stage.

Dormancy

This stage lasts from autumn to the following spring. The plant's dormant period is indicated by the fall of the crown. The growth of the vegetative parts is suspended, but the plant's vital activity does not stop. That is why we can only speak of relative dormancy. In order for the dormant period to occur in any case, a radical decrease in temperature must occur (vernalization). Without the dormant state, the formation of flower buds in the following spring would not be possible. The effect of cold is one of the basic conditions for flowering.

Chapter 10

Crown formation of fruit trees

In order to harvest the desired quality and quantity of fruit, we need to form a crown on fruit trees that meets the purpose. The requirements for the crown are very diverse. Carrying capacity, proper proportion, and good light and air supply are determining factors in maintaining productivity. We should always start forming the crown during the fruit tree's development stage, but we must indicate the type of crown to be formed in advance in the plantation plan, as this largely determines the space requirements of the plantation. Choosing the right space requirement also plays a role in the crown's fertility, photosynthesis and plant protection. In a plantation that is too dense, the crown has difficulty assimilating, which disrupts the tree's biological cycle. A dense crown is also more susceptible to fungal infections. The correct ratio of crown to trunk must also be adjusted for harvesting. A high stem is more efficient when harvest by machine, and a lower stem is more efficient when harvest by hand. When harvesting with a shaker mashine, always create a strong, low trunk. The formation of fruit tree crowns is possible in several groups. In our note, we analyze the following group:

Conventional crowns:

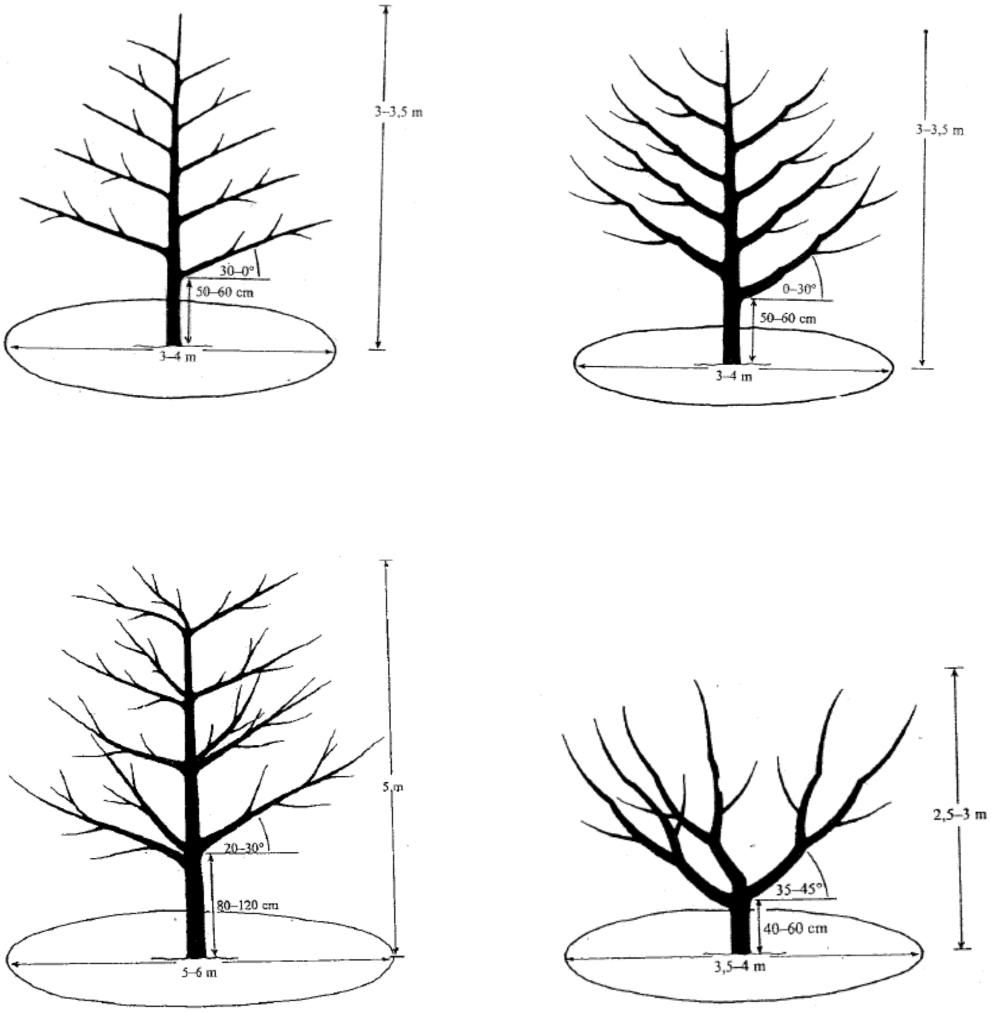


Figure 4-5-6. Round-shaped conventional crowns

The crown type of fruit species and varieties grafted onto strong rootstocks is. At the beginning of its formation, the curve is left, but it is removed above the last branch. This creates a smaller bowl. There are two ways to achieve the combined form. In the case of the combined crown form with branch groups, the trunk branches form tiers opposite each other. The distance between tiers is 60-70 cm. The branches of the combined crown with a spreading position are arranged in a spiral pattern on the trunk. The distance between the branches above each other is also 60-70 cm. It is used in the cultivation of cherries, sour cherries, apricots, plums and pears.

Intensive type crowns:

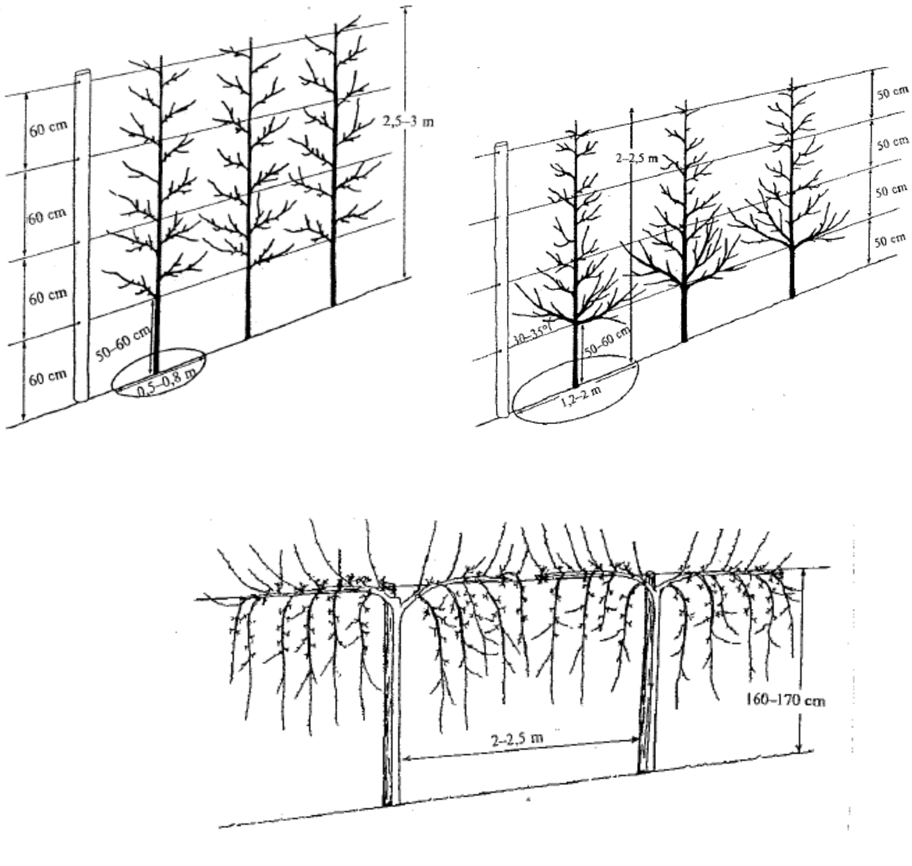


Figure 7-8-9: Round-shaped intensive type crowns

They were developed in Germany and Holland, but is now used throughout Europe. A modern, easy-to-manage crown type. When planted, the row and plant spacing are extremely small, barely reaching 1 m. It quickly turns to fruit, and starts to bear fruit the year after planting. It is pruned mainly in August, using half-tree pruning. Its trunk height is only adjusted after it turns to fruit. Rootstock is a particularly weak grower M 9, M 27.

Chapter 11

The grafting of fruit trees

“*We call grafting all those procedures where we grow branches, twigs, canes, buds or shoots together*!” (Árpád Jeszenszky)

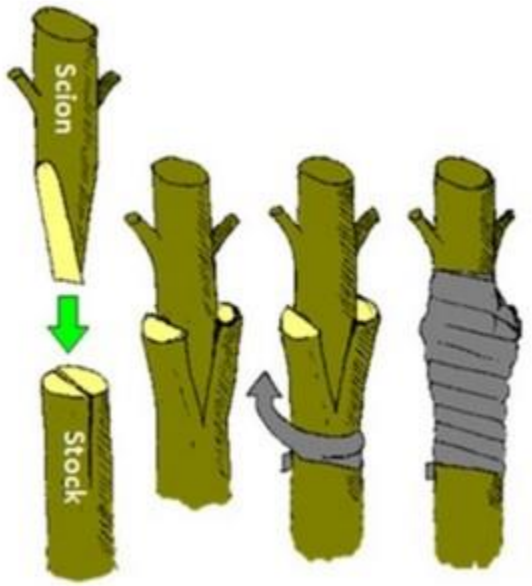


Figure 10. Grafting of fruit trees

One of the basic conditions for grafting is the union of the two plants. Grafting is nothing more than grafting a part of the plant we have chosen as a scion plant onto the plant intended as the rootstock. Different methods of vaccination are possible. Whichever method you choose, you will need to make a wound on both plants so that they can fuse together to form one plant (graft). The condition for intergrowth is that only plant species and varieties belonging to the same plant family can be grown together. Wounds on plants heal only on the wound surface along the contact of dividing (cambial) tissues. The dividing tissue of dicotyledons is located between the inner phloem tissue of the bark and the xylem tissue. During grafting, it is important that the two cambial tissues come into contact over as large a surface area as possible. The wound surfaces should overlap tightly, with no gaps between them. Care must also be taken to ensure that the wound surfaces do not move!

The grafting can be done at two times. One is in early spring, when the sap flow of the rootstock is still at its beginning. The other is at the end of September, when the leaves are falling. At this time, the sap flow has already decreased significantly.

Chip-budding

The budding mechanism can only be successful if the rootstock is growing. Budding can also be used on plants with tuberous stems. The budding shoot should be mature, with mature leaves and developed buds. The bud is cut off together with the thin skin tissue underneath, which is called the bud shield. The bud can only be a generative bud! We distinguish two types of budding:

- **sleeping budding**

The bud removed with the bud shield is placed in a T-shaped cut prepared in the rootstock. The bark of the rootstock must be easy to cut, therefore the sap circulation of the rootstock is important. The bud shield is inserted precisely under the T groove, taking care not to make any rough skin. If the budding area is adequate, the entire budding area is tied with raffia. While tying, make sure that the bud does not move. In the case of cherries, the bud is protruding, so the tying is carried under the bud shield. After this, the bud is evenly covered with seed wax. The time for sleeping budding is planned for the second sap circulation, i.e. August-September. The bud placed on the rootstock will grow together within a few weeks, but will not sprout that year. It “sleeps” for a winter and only sprouts the following spring. On the 18^{th} day after the seeding, the seed is examined; if it is not black and has a smooth surface, the seeding is successful. The raffia should be removed on the 21^{st} day.

- **active budding**

The active budding is planned for the first sap flow, i.e. for the spring months. The buds will sprout shortly at this time, so the rootstock is pinched back to 15 cm immediately after budding. We leave a single wild shoot, the sucker shoot, and remove the rest. The budding is carried out in the same way as the dormant budding.

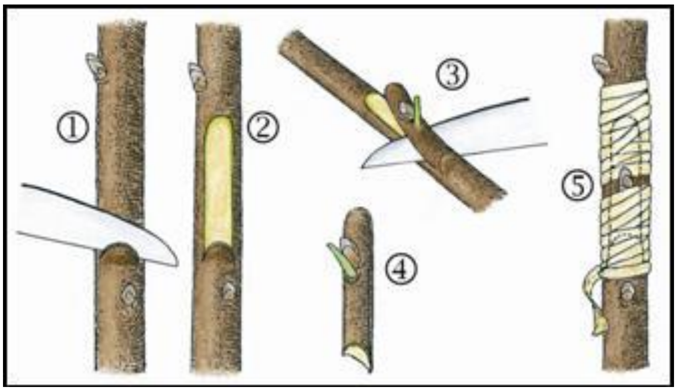


Figure 12. Mechanize of active budding

Chapter 12

Fertilization of fruit trees

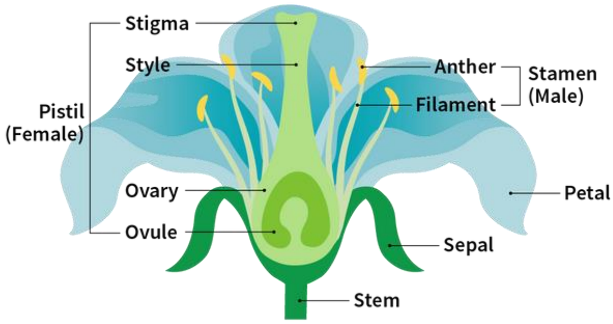


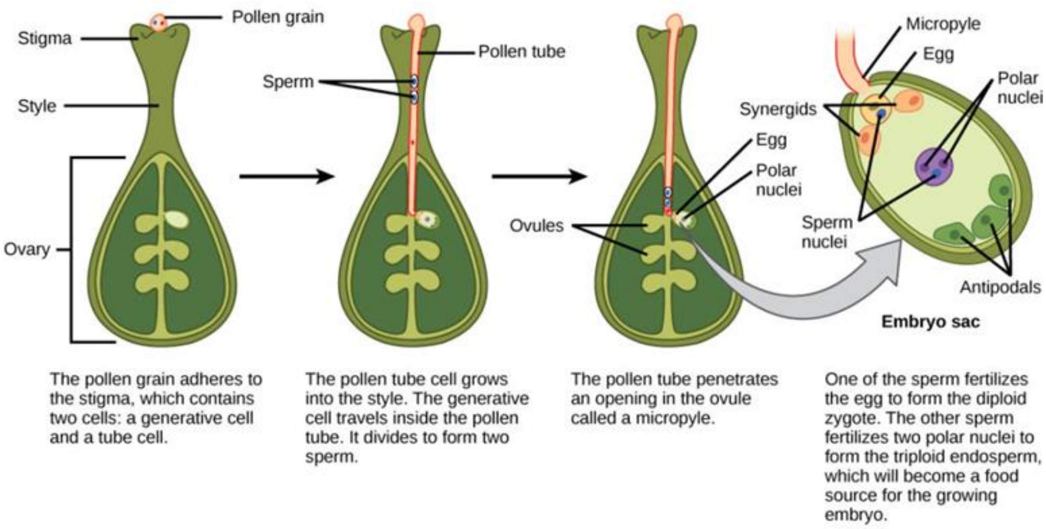
Figure 13. Anatomy of flower

Most of our fruit-bearing plants have unisexual, monoecious flowers, which are located in branches. Because both sexes, pistils (female) and stamens (male), are found within the same flower, it is called hermaphrodite. The exceptions to this are walnuts, hazelnuts and chestnuts. However, most of our cultivated fruit trees are self-infertile, meaning they are unable to reproduce within their crown. It lost this property during breeding, or due to an enzyme deficiency, the anthers are unable to open and therefore cannot fertilize. In this case, the planting plan must take into account fertility factors, and the use of so-called pollinating varieties becomes necessary. We will hereinafter call these varieties pollinators or donor! At least two pollinating varieties (but a third is also possible) should be planted, either every 3rd or 5th row in each row, or every 3rd or 5th row should be donor. The work of bees is of enormous importance in this task. Wild bees are active at 20-21°C, which requires optimal air movement and humidity. Persistent rain, temperatures below 10°C and winds of 15-20 km/h reduce bee foraging activity. In the case of wind-pollinated fruit plants, however, we can only rely on air movement.

The requirements for a pollinator variety are:

- it should bloom regularly every year,
- it should overlap with the variety to be pollinated by at least 50% in terms of main flowering time,
- it should provide healthy pollen,
- it should have stable flowering,
- it should not have any conflicts of interest with the variety to be pollinated,
- it should be a marketable, valuable variety.

Figure 14. Double fertilization (internet)



The pollen grain falling on the pistil consists of a single information-containing cell. The pollen grain cell that adheres to the appropriate pistil divides into two, then forms a vegetative and a generative cell. The vegetative cell creates a tube in the internal tissue of the fruit, which penetrates to the germ gate of the seed primordium, because here the embryo sac is left more freely by the seed primordium envelope. Behind the vegetative cell, two sperm cells formed from the generative cell travel. The seed is located in the seed coat, its most important part is the embryo sac, which consists of 8 cells. One is the egg cell, the two next to it are the two companion cells, the cells opposite it are the antipodal cells. These can take over the role of the egg cell if the egg cell is damaged. The two cells located in the middle of the embryo sac fuse and form a central cell. One of the two sperm cells fertilizes the egg cell, from which the seed germ, i.e. the new plant, develops. The other fertilizes the central cell, from which the seed's nutrient tissue is formed

Table 2. Fertilization of fruit trees and shrubs

Species	self-sterile	foreign pollinator	self-fertile
apple	x		
pear	x		
medlar, quince			x
cherry	x		
sour cherry	x		x
plum	x		x
apricot		x	x
peach			x
walnut	x		x
almond	x		
raspberry		x	
currant		x	
gooseberry		x	

Fruit ripening

Ripening is the final stage of fruit development. During this stage, the fruit reaches a state suitable for consumption and processing. Ripening is a qualitative change during which biochemical transformations take place in the fruit. In this regard, we distinguish between fruits that ripen later and fruits that cannot ripen later. Among the latter, we can primarily mention apple and banana producers. In the case of post-ripening fruit, the fruit continues to live after being separated from the plant, and the biochemical processes taking place within it allow its flavor, color, and ripening to occur. Fruits that are incapable of post-ripening, on the other hand, cannot ripen further once they are picked, but only reach their full value on the tree or bush. Based on these, we talk about climacteric and non-climacteric fruits. During fruit ripening, degradation and synthesis processes occur that determine the fruit's taste, content and ripening time. The production of ethylene is essential for fruit ripening. Pruning is an important practical task in fruit production. With pruning procedures, we can modify several biological and physiological factors during the cultivation of our plants, and we introduce these changes into fruit gardening for the sake of more successful and efficient fruit production.

The changes that can be created and formed by pruning can be the following:

- Harmonious formation of vegetative and generative plant parts,
- creating fruit balance, forming the size and shape of the crown,
- regulating the dynamics of nutrient transpiration, removing diseased, frozen, damaged parts,
- rejuvenating older parts.

Table 3. Chemical and physical changes during fruit ripening

Decomposing processes	Syntheses
chloroplast disintegration	anthocyanins, carotenoids and xanthophylls formation
chlorophyll breakdown	formation of odorants
starch hydrolysis	formation of sugar
decomposition of acids	increased activation of the Krebs cycle
oxidation of respiratory substrates	increasing ATP levels
inactivation of phenolic compounds	the pathways of ethylene formation
dissolution of pectin substances	
activation of hydrolytic enzymes	
increased permeability of cell membranes	
softening of the cell wall	

Apple (*Malus domestica* Borkh.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Malus*
Species:	***M. domestica***

Its genetic center is Asia. It can be grown safely in the temperate zone. In Hungary, it grows in any part of the country.

Morphology

A fruit-bearing tree. Its root system, depending on the propagation of the rootstock, can be adventitious (in the case of vegetative propagation) or taproot (in the case of generative propagation). Its trunk has smooth bark, and its crown can be formed into almost any crown type.

Flower

A panicle inflorescence, which is bisexual, monoecious, and self-sterile. When grown, it is necessary to use a pollinator variety.

Fruit

Apple fruit.

Growing requirements

- Requires medium-rich, warm, airy soils, grows well on sandy soils, pH 5.7-7,
- heat-requiring, sensitive to late spring frosts, especially during flower setting,
- water-requiring, 600-800 mm rainfall requirement,
- nutrient requirements: N 0.2kg P_2O_5 0.06kg K_2O 0.3kg for 100 kg of yield, 40-50 t/ha organic fertilizer before planting,
- soil liming ($CaCO_3$) is required every 3 years,
- its light requirements are satisfied by the Hungarian conditions.

Propagation

- vegetatively by grafting or budding,
- generatively by seeding only the rootstock.

Cultivability

Apples can be grown well in conventional, organic and intensive production systems (a plantation of 2000 trees/ha can be considered intensive production).

Crown shapes

- combined crown,
- terminal spindle,
- free spindle,
- slim spindle,
- super spindle,
- garland spindle,
- apple hedges (Hungária, Busche-Thomas, Palmetta),
- apple curtain.

Rootstock

- strong growing wild rootstock,
- medium growing M4,
- weak growing M 9, M 26, M 27.

Planting

After proper soil preparation, the operation should be carried out in the fall before the onset of frost. It can be done with hand tools or a planting machine. When planting, we must pay attention to a healthy root system and crown. We can use crown grafting or sapling for the installation.

Ripening

Based on the ripening time of apples, the following groups are distinguished:

- summer apples: (e.g. Astrakhan red, Éva, Summery juicy, Summerred)
- autumn apples: (e.g. Cox orange renet, Kovelit, Príma)
- winter apples: (e.g. Delicious, Mutsu, Granny Smith)

Plant protection

We analyze the plant protection of fruit trees by dividing it into two periods. The first important period is the application of plant protection measures before planting. These are mainly preventive plant protection measures against soil disinfection and root-damaging fungi, bacteria, and soil-dwelling (terricolous) pests. The other, longer, annually repeated plant protection period covers the cultivation period.

Adrastus rachifer larvaja

Melolontha melolontha larvaja

Anthonomus pomorum

Lespeyresia pomonella

Adoxophyes reticulana

Panonicus ulmi

Aphis pomi

Quadraspidiotus perniciosus

Agrobacterium tumefaciens

AMV

Venturia inaqualis

Podosphaera leucotricha

Monilia fruchtigena

Erwinia amilovora

Peach (*Persica vulgaris* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Prunus*
Species:	***P. persica***

Its genetic center is the southern part of China. In the temperate zone, it can only be grown safely in warmer regions. In Hungary, the southern slopes of the Mecsek Hills provide the best conditions for its cultivation.

Morphology

A fruit-bearing tree. Its roots are richly branched, its trunk is brownish-gray. Its leaves are lanceolate.

Flower

A panicle inflorescence, which is bisexual, monoecious, and self-fertile.

Fruit

Hard-shell. The skin may be downy or glabrous.

Propagation

- vegetatively, by grafting or budding,
- generatively, from seed, only the rootstock is propagated.

Growing requirements

- Medium-compact, warm, slightly calcareous soils,
- extremely frost-sensitive, frost pockets should be avoided during planting,
- water-intensive, 600-700 mm rainfall requirement, construction of an irrigation system is advisable,
- irrigation equipment is required during cultivation,
- nutrient requirements N 0.3 kg P_2O_5 0.16 kg K_2O 0.9 kg for 100 kg of yield,
- 40-50 t/ha organic fertilizer before planting, spring top dressing is recommended, e.g.: $NH_4NO_3 + CaCO_3 + MgO_2$

Cultivability

Peaches can be grown well in conventional, organic and intensive production systems.

Crown shapes

- spotless crown
- vase form crown
- slender spindle (on wild peach rootstock)

Its rootstocks

Strong-growing wild apricot and mirabolla, weaker-growing rootstock is bitter almond.

Breeding goal

- Increase frost resistance,
- breeding nectarines,
- develop resistance.

Planting

After proper soil preparation, the operation is carried out in the fall before the onset of frost. When planting, we must pay attention to a healthy root system and crown. Planting is carried out with hand tools or a planting machine. For the installation, we can use crown grafting or cuttings.

Plant protection

(Myzus persicae)

(Anarsia lineatelle)

(Grapholitha molesta)

(Agrobacterium tumofaciens)

(Annulus pruni)

(Taphrina deformans)

(Sphaerotheca pannosa)

(Stigminia carpophila)

(Monilia laxa)

Cherry (*Prunus avium* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Subfamily:	Amygdaloideae
Tribe:	Amygdaleae
Genus:	*Prunus*

Its genetic center is Asia, it can be grown safely in the temperate zone. In Hungary, it is grown intensively in Nyírség, Csongrád County and between the Danube and Tisza rivers.

Morphology

A fruit-bearing tree. It develops a taproot system, its trunk is grayish, reddish-brown. Its leaves are egg-shaped, its buds are shiny red.

Flower

A racemose inflorescence that develops in a raceme. It is dioecious, monoecious, self-fertile. During its cultivation it is necessary to use pollinating varieties. Bees play an important role in its fertilization.

Fruit

Hard-shell fruit.

Breeding goal

- Intra-crown fertilization,
- early fruiting,
- development of winter hardiness and resistance,
- reduction of crown size.

Cultivation requirements

- medium-compact, deep, slightly calcareous soil,
- medium water requirements, 500-600 mm rainfall requirement,
- excessive water absorption can easily cause the fruit's skin to tear and crack,
- heat-requiring, buds and flowers are sensitive to spring frosts (damaged below -2 °C),
- nutrient requirements N: 0.5 kg P_2O_5 0.14 kg K_2O 0.6 kg for 100 kg of fruit,
- 40-50 t/ha organic fertilizer before planting, $Ca(NO_3)2$ fertilizer is recommended in spring.

Cultivability

Cherry can be grown well in conventional, organic and intensive production systems.

Crown shapes

- combined crown
- free spindle
- improved Brunner spindle
- slender spindle
- vase form crown

Rootstock

- the cherry rootstock has strong growth,
- the colt rootstock has medium growth.

Propagation

- vegetatively, by grafting or budding,
- generatively, from seed, only the rootstock is propagated.

Planting

After proper soil preparation, the operation should be carried out in the fall before frost sets in. It can be done with hand tools or a planting machine. When planting, care should be taken to ensure a healthy root system and crown. For the installation, crown grafting or sapling can be used.

Plant protection

(Adrastus racifer larvaja)

(Melolontha melolontha larvaja)

(Rhagoletis cerasi)

(Caliroa limacina)

(Myzus cerasi)

(Agrobacterium tumofaciens)

(Monilia laxa)

(Blumeliella jaapii)

(Phoma pomorum)

PNRSV *(Prunus necrotic ringspot ilarvirus)*

Sour cherry (*Prunus cerasus* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Prunus*
Subgenus:	*Prunus* subg. *Cerasus*
Species:	***P. cerasus***

Its genetic center is Asia and Southern Europe, and it can be grown safely in the temperate zone. In Hungary, Újfehértó and Békés towns, Eger and the area around Lake Balaton provide good conditions for its cultivation. In the countryside, it is often used as an ornamental tree along ditches.

Morphology

Fruit tree. Its root system is wide-spreading, not deep-penetrating. Its trunk is brown. Its leaves are regular, with slightly serrated edges.

Flower

A panicle inflorescence that develops in a cluster. It is dioecious, monoecious, self-sterile. During its cultivation the use of pollinating varieties is necessary. Bees can play an important role in its fertilization.

Cultivability

Sour cherries can be grown well in conventional, organic and intensive production systems.

Growing requirements

- medium-compact, airy, deep-layered, calcareous soil,
- medium water requirement, 500-600 mm rainfall requirement,
- not heat-demanding, one could say frost-resistant,
- nutritional requirements N 0.5 kg P_2O_5 0.14 kg K_2O 0.6 kg for 100 kg of yield,
- 40-50 t/ha of organic fertilizer before planting, soil liming is recommended every 3 years.

Crown shapes

- combined crown
- vase form crown
- free spindle

Its root stock

Same as that of the cherry.

Planting

After proper soil preparation, the operation should be carried out in the fall before the onset of frost. When planting, care should be taken to ensure a healthy root system and crown. The installation can be carried out with hand tools or a planting machine. Crown grafting or grafting can be used.

Plant protection

Very similar to that of the cherry.

Apricot (*Armenica vulgaris* Lam.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Prunus*
Subgenus:	*Prunus* subg. *Prunus*
Section:	*Prunus* sect. *Armeniaca*

Regarding its origin are China, Siberia and Europe can also be considered. It can be grown in temperate climates, and in Hungary, Szeged, Pécs, Cegléd and the area around Lake Balaton provide sufficient ecological requirements for its cultivation. In our country, we consider it as a Hungaricum.

Morphology

Fruit tree. Taproot system, which is located shallowly in the soil. Its trunk is straight, the bark is cracked, the leaves are egg-shaped, its crown is so-called: natural crown.

Flower

A panicle inflorescence, which is bisexual, monoecious, self-fertile, but during its cultivation, the use of a pollinator is also necessary.

Fruit

Hard-shell fruit.

Propagation

- vegetatively by grafting,
- generatively by seedlings.

Growing requirements

- medium-compact, warm, airy, slightly calcareous soil,
- heat-requiring, likes long-lasting sunlight, extremely sensitive to frost,
- medium water requirement, 500-600 mm rainfall requirement,
- will die out in case of high groundwater level (not above 2 m!),
- nutrient requirement N 0.4 kg P_2O_5 0.13 kg K_2O: 0.6 kg for 100 kg of yield,
- 40-50 t/ha organic fertilizer before planting, top dressing recommended in spring e.g.: saltpeter

Breeding goal

- improving climate resistance,
- better fruiting within the crown,
- developing resistance and tolerance (against bacteria).

Cultivation

Apricots can be grown well in conventional, organic and intensive production systems.

Crown shapes

- combined crown
- vase form crown
- free spindle
- slender spindle
- improved Brunner spindle
- Papp's umbrella

Planting

After proper soil preparation, the operation is carried out in the fall until the onset of frost. When planting, take into account the groundwater level, pay attention to a healthy root system and crown. Avoid frost-prone areas. Crown grafting or grafting can be used for planting. If we decide to create a natural crown, we must ensure sufficient space for undisturbed growth. ($20\text{-}25 m^2$/tree).

Plant protection

Same as for peach, except for one pathogen.

Plum (*Prunus domestica* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Prunus*
Subgenus:	*Prunus* subg. *Prunus*
Section:	*Prunus* sect. *Prunus*
Species:	***P. domestica***

Its genetic center is Asia and the Black Sea region. It can be grown with great safety in the temperate zone. In Hungary, it is cultivated intensively in Hajdúság, Borsod and Heves and Pest counties. In the countryside, it is often used as an ornamental tree along ditches.

Morphology

A fruit-bearing tree. Its root system is a strong taproot. Its trunk is silvery, its leaves are elliptical shaped.

Flower

A racemose inflorescence, which is bisexual, monoecious, self-fertile. It flowers very early.

Fruit

Hard-shell fruit.

Propagation

- vegetatively by grafting,
- generatively by seed only the rootstock is propagated.

Cultivation requirements

- medium-compact, deep, slightly calcareous soil,
- medium water requirements, 500-600mm rainfall requirement,
- flowers are not sensitive to frost but the crown likes sunshine,
- 40-50 t/ha organic fertilizer before planting, soil liming recommended every 3 years ($CaCO_3$),
- nutrient requirements N 0.6kg P_2O_5 0.18kg K_2O 0.9kg for 100kg yield

Cultivability

Plums can be grown with great safety in conventional, organic and intensive production systems.

Crown shapes

- vase form crown
- combined crown
- improved Brunner spindle
- slender spindle
- free spindle

Its rootstocks are:

Mirabolan,

GF 43.

Plant protection

(Adrastus rachifer larvaja)

(Melolontha melolontha larvaja)

(Grapholitha funebrana)

(Hoplocampa minuta)

(Schizotetranycus pruni)

(Aphididae sp.)

(Agrobacterium tumofaciens)

(Plum pox potyvirus)

(Taphrina pruni)

(Polystigma rubrum)

(Podosphaera tridactyla)

(Tranzschelia pruni spinosa)

Pear (*Pyrus communis* L.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Subfamily:	Amygdaloideae
Tribe:	Maleae
Subtribe:	Malinae
Genus:	*Pyrus*

Its genetic center is Asia. It can be grown in the temperate zone. In Hungary it is grown intensively in Zala, Pest and Somogy counties.

Morphology

A fruit tree. Its root system is the same as that of the apple. Its trunk is grayish-brown. Its natural crown is candle-shaped.

Flower

A panicle inflorescence, which is bisexual, monoecious, and self-sterile. When grown, it is necessary to use a pollinator.

Fruit

Apple fruit.

Breeding goals:

- intra-crown fertilization,
- tolerance of extremes,
- refinement of stone cells (butter pear),
- increasing resistance, resilience, reducing growth vigor.

Cultivation requirements

- medium-compact, airy, warm, deep soils,
- heat-demanding, less tolerant of extreme weather,
- water-demanding, 600-800 mm rainfall requirement,
- nutrient requirements N 0.2kg P_2O_5 0.06kg K_2O 0.3kg for 100kg yield,
- 40-50 t/ha organic fertilizer before planting, soil liming ($CaCO_3$) required every 3 years,
- $CaNO_3$ foliar fertilizer recommended in spring,
- its light requirement is satisfied by domestic conditions.

Propagation

- vegetatively by grafting or budding,
- generatively by seeding only the rootstock

Cultivability

Pears can be grown well in conventional, organic and intensive production systems.

Crown shapes

- combined crown
- free spindle
- slender spindle
- hedge crown (Hungarian hedge)

Its rootstocks:

- wild pear and quince are strong-growing.
- hawthorn is dwarf-growing.

Planting

After proper soil preparation, the operation should be carried out in the fall, before the onset of frost. It can be done with hand tools or a planting machine. During the process, care must be taken to ensure a healthy root system and crown. For planting, crown grafting or sapling can be used.

Ripening

Based on the ripening time of the pear, the following groups are distinguished:

- summer pears (e.g. Clapp's favorite, Red clapp, Vilmos),
- autumn pears (e.g. Bosc cobak, Conference),
- winter pears (e.g. Hardepont winter butter pear, Winter bishop).

Plant protection

(Adrastus rachifer larvaja)

(Melolontha melolontha larvaja)

(Psylla pyrisuga)

(Laspeyresia pyrivor)

(Hoplocampa brevis)

(Aphis pomi)

(Pannonicius ulmi)

(Agrobacterium tumofaciens)

(Venturia pirina)

(Mycosphaerella sentina)

(Monilia fruchtigena)

(Gymnosporangium sabinae)

(Erwinia amilovora)

Walnut (*Juglans regia* L.)

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Fagales
Family:	Juglandaceae
Genus:	***Juglans***

It can be originated from America, Asia and Europe. It can be grown in temperate climates, and in Hungary it is mainly grown along the Tisza River.

Morphology

A fruit tree. Its strong taproot system is located deep in the soil. Its leaves are oval, very large in size.

Flower

It is unisexual, monoecious, wind-pollinated, self-fertile. The bark is not covered with scale leaves, so it is sensitive to early spring frosts. The effect of poor fertilization on the fruit causes the so-called "papery skin".

Propagation

- generatively grown as seedlings,
- possibly grafted onto American black walnut rootstock.

Fruit

A shelled fruit.

Breeding goal

- early maturity,
- improvement of frost resistance,
- development of resistance.

Cultivability

Walnuts can be grown well in conventional and organic production systems. Due to the large space requirement of the crown, we cannot use them in intensive production systems. However, their fruiting ability can be improved through breeding work.

Cultivation requirements

- good water holding capacity, loose, humus-rich soil,
- high water requirements, 1000 mm rainfall requirement,
- heat-requiring, the crocus inflorescence is sensitive to spring frosts,
- nutrient requirements N 1.1 kg P_2O_5 0.2 kg K_2O 1.7 kg for 100 kg of yield,
- 40-50 t/ha organic fertilizer before planting, spring top dressing should be carried out after the crop starts to grow

Plant protection

(*Zeuzera pyrina*)

(*Aceria arineus*)

(*Aphididae*)

(Agrobacterium tumofaciens)

(Xantomonas arboricola pv. Juglandis)

(Gnomonia leptostyla)

Strawberry (*Fragaria vesca* Duch.)

Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Eudicots
Clade:	Rosids
Order:	Rosales
Family:	Rosaceae
Genus:	*Fragaria*
Species:	***F.* × *ananassa***

Wild strawberries (forest strawberries) are native in America, Asia and Europe. The cultivated strawberry is *Fragaria ananassa*, the result of a spontaneous cross. Strawberries are grown in Leányfalu, Pomáz, on the border of Veresegyháza, and around Kecskemét and Szeged in Hungary.

Morphology

A soft-stemmed, perennial fruit-bearing plant that develops generative (fruit-bearing) and vegetative (shooting) vines.

Flowers

Bisexual, monoecious, self-fertile. Its flowers and fruits always develop on the generative vines.

Fruit

A multiple fruit.

Propagation

Strawberries are propagated from vegetative shoots using seedlings.

Cultivability

In the case of arable farming of strawberries, if we use a single-row planting, the seedlings should be planted in the autumn at a distance of 90x20 cm between rows. In the case of twin-row cultivation, the row spacing between twin rows should be 30 cm, and the distance between 2-2 twin rows should be 90 cm. In the case of arable farming of strawberries, its life cycle is similar to the biological cycle of fruit plants. From spring to mid-summer, the development of the vegetative parts increases, at the same time flowering and fruiting also start. At the end of summer, its growth stops, and in autumn, the period of fruit bud differentiation occurs. From late autumn, there is a dormant period.

Strawberries can be grown continuously in heated greenhouses or in a growing system with a foil tent all year round. Day-neutral species bloom and produce continuously all year round. Their nutrient supply is also continuous. Their cultivation is only possible in growing systems.

Cultivation requirements

- medium-compacted, sandy, loamy soil, pH between 5-7,
- heat-requiring, must be protected against winter frosts with mulch (manure),
- water requirement 600-800 mm rainfall, it is advisable to build an irrigation system during cultivation,
- it does poorly on soils with high groundwater, salt and CaCO3 content,
- nutrient requirement 40-50 t/ha of organic fertilizer is incorporated in the year before planting,
- complex fertilizer is applied continuously through the drip irrigation system during the growing season.

Plant protection

(*Tetranychus ultriae*)

(*Aphis forbesi*)

(*Ancylis comptana*)

(Phytophthora cactorum)

(Sphaerotheca macularis)

(Mycosphaerella fragariae)

(Botrytis cinerea)

Chapter 13

Effect of fruits for human body

Fruits should be an important part of your daily diet. They are naturally good and contain vitamins and minerals that can help to keep you healthy. They can also help protect against some diseases. Fruits are at their best when they are in season. Otherwise try frozen or canned fruits as they are just as nutritious and budget-friendly as well. Fruits contain many vitamins and minerals that are good for your health. Many of these are antioxidants, and may reduce the risk of many diseases: vitamin A (beta-carotene), vitamin C, E, magnesium, zinc, phosphorous and folic acid.

Summary

- Fruits contain important vitamins, minerals and plant chemicals. They also contain fibre.
- There are many varieties of fruit available and many ways to prepare, cook and serve them.
- A diet high in fruit can help protect you against cancer, diabetes and heart disease.
- Eat 2 kinds of fruit every day for good health.
- Most Hungarians do not eat enough fruit.
- When buying and serving fruit, aim for variety to get the most nutrients and appeal.

Chapter 14

Viticulture

Botanical classification of grape

The species of the genus Vitis are classified into 2 species groups:

- **Euvitis**

The vines belonging to this species group are widespread in North America, East and West Asia, and Europe. They are cultivated in the temperate zone. Their species groups and distribution (according to Galet) are as follows:

· Candicansoideae (New Mexico)

· Labruscae (Japan, Korea, Manchuria)

· Caribeae (India, Borneo, South China)

· Arizonae (western USA, Mexico)

· Cinereae (Texas)

· Aestevalae (eastern USA)

· Cordifoliae (eastern USA)

· Flexuosae (East Asia)

· Spinosae (China)

· Ripariae (Texas, Colorado)

· Viniferae (Eurasia)

- **Muscadinia**

Representatives belonging to this species group are present in the southeastern part of the USA from Delaware to Florida. They are cultivated on the subtropical and tropical coasts of the Atlantic Ocean. Their species groups:

· *Vitis rotundifolia,*

· *Vitis minsoniana,*

· *Vitis popenoei.*

Table 1. Botanical classification

Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Vitales
Family:	Vitaceae
Genus:	***Vitis***

„The Middle East is generally described as the homeland of grapes and the cultivation of this plant there began 6,000–8,000 years ago. Yeast, one of the earliest domesticated microorganisms, occurs naturally on the skins of grapes, leading to the discovery of alcoholic drinks such as wine. The earliest archaeological evidence for a dominant position of wine-making in human culture dates from 8,000 years ago in Georgia.

The oldest known winery, the Areni-1 winery, was found in Armenia and dated back to around 4000 BC. By the 9th century AD, the city of Shiraz was known to produce some of the finest wines in the Middle East. It has been *proposed that Syrah red wine is named after Shiraz, a city in Persia where the grape was used to make Shirazi wine.*

Ancient Egyptian hieroglyphics record the cultivation of purple grapes, and history attests the ancient Greeks, Cypriots, Phoenicians, and Romans growing purple grapes both for eating and wine production. The growing of grapes would later spread to other regions in Europe, as well as North Africa, and eventually in North America. „

Chapter 15

Morphology of grape

Grapes can be propagated generatively from seeds or vegetatively from cuttings. Since the phylloxera epidemic, grapes have been propagated vegetatively in our country, and seedlings can only be grown on sandy soils. A vegetatively propagated grape consists of an underground root system and an above-ground stem and its various branches. The parts of a grape are shown in the figure below.

Rooting of stem cuttings used in vegetative propagation always occurs with adventitious roots. The task of the roots is to absorb and transmit nutrients to the grapevine, as well as to store some of them. The grapevine can absorb nutrients in a dissolved, ionized state. In young vines, the taproots outgrow the development of other roots, but in older vines this is no longer differentiated. The number of roots on young vines can initially be several thousand, but this number decreases later. In older vines, the mass of hairy roots increases. The mechanism of root system development is determined by the species, variety, soil, and the amount of available water. Based on these, we distinguish between extensive (less branched root system) and intensive (densely branched root system) types. The former type is, for example, Kövidinka, the latter is Cabernet Franc.

Taproot

The taproot develops from the underground, rooting part of the smooth shoot intended for propagation. The upper part of the taproot is the part of the root collar directly below the soil surface, which is connected to the vine stem. Taproot develops from the lowest bud of the shoot. It is the thickest and most extensive part of the root system. It is important that they develop at the right depth (3-4 m) to be protected from drying out and frost along the ground.

Lateral roots

Thinner roots that develop from the central buds of the shoot. They completely cover the area between the taproot and the soil level (9-12 m2).

Dew roots

They form close to the soil surface or can originate from the buried root collar and taproot. They are very thin, undesirable roots, so we usually remove them in the nursery. Since they form close to the soil surface, they would be constantly exposed to drought and frost along the ground.

Hair roots

The final branches of the roots are the taproots. With the help of the root hairs formed on their surface, the vine absorbs dissolved nutrients, which reach the taproot through the base or lateral roots. The taproot transmits the nutrients that pass through it to the taproot, shoots, and then to the leaves. The nutrients formed in the leaves are then returned to the roots in the same way

Stem

The oldest, thickened part of the grapevine above ground. Its shape can be diverse and varied. The low, spherically thickened part is the stem. The trunk consisting of one or more parts, thinning upwards, is called the thigh, the vertically thickened trunk is called the arch trunk, and the horizontally formed and thickened branch is called the cordon arm.

The 3-4-year-old woody branch starting from the stem is the buck or horn. The 2-year-old branch is the sapling, and the annual woody shoot is the cane. The cane left on the pruned rootstock is classified according to the number of buds on it:

1-2 buds = short cane,

3-5 buds = long cane,

6-8 buds = short cane,

more than 8 buds = long cane.

Shoot and cane

The young, green growth that develops from the bud is called a shoot, while the woody shoot is called a cane. The tip of the grape shoot is called a sail. The quality of the sail varies from species to species. The cane is divided into segments by thickened stem nodes. The distance between two segments is called an internode.

Bud (eye)

The reproductive and fruit-bearing part of the grape. Each bud of the grape is capable of developing shoots and adventitious roots, but cannot bear fruit. On the shoot, we find the summer bud and the overwintering or light buds in the leaf axils. The axillary shoot is formed from the summer bud, and new buds develop from these. The lowest, undeveloped buds are called mud eyes, and the buds that are embedded in the bark on the stem are called dormant (latent) buds. The bud therefore grows shoots, forms adventitious roots and can also bear flowers.

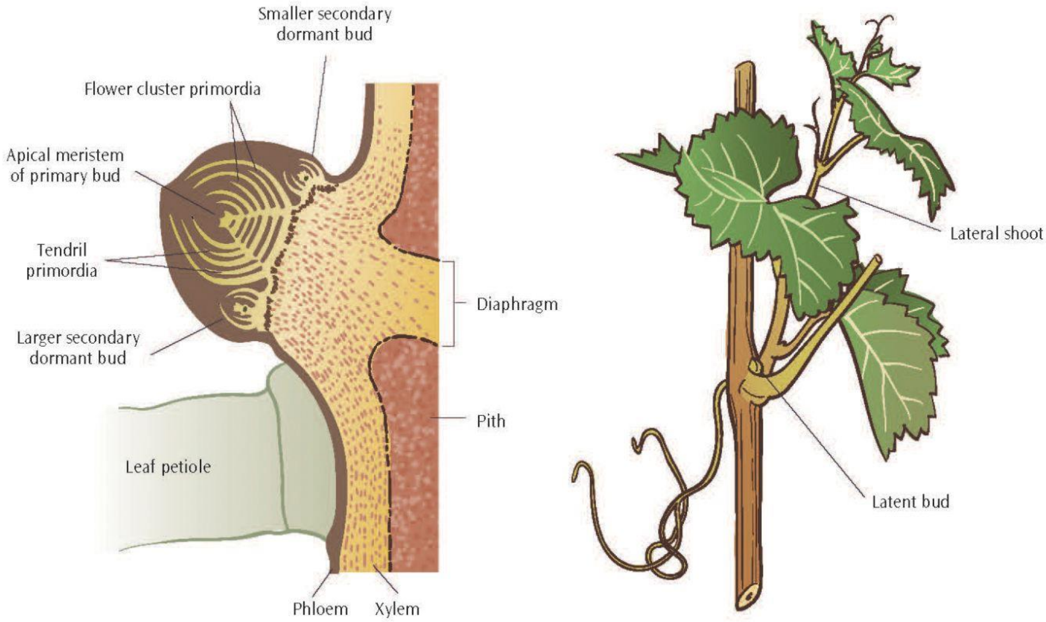


Figure 1. Bud and shoot of grape

Leaf

We find opposite leaves at each end of the shoot. Their role is in the mechanism of photosynthesis, respiration, plant thermoregulation and nutrient uptake. Their shape, size, surface, and underside depend on the species and variety.

Tendril

A modified inflorescence used for clinging. It is located opposite the leaf, but is not a lateral bud.

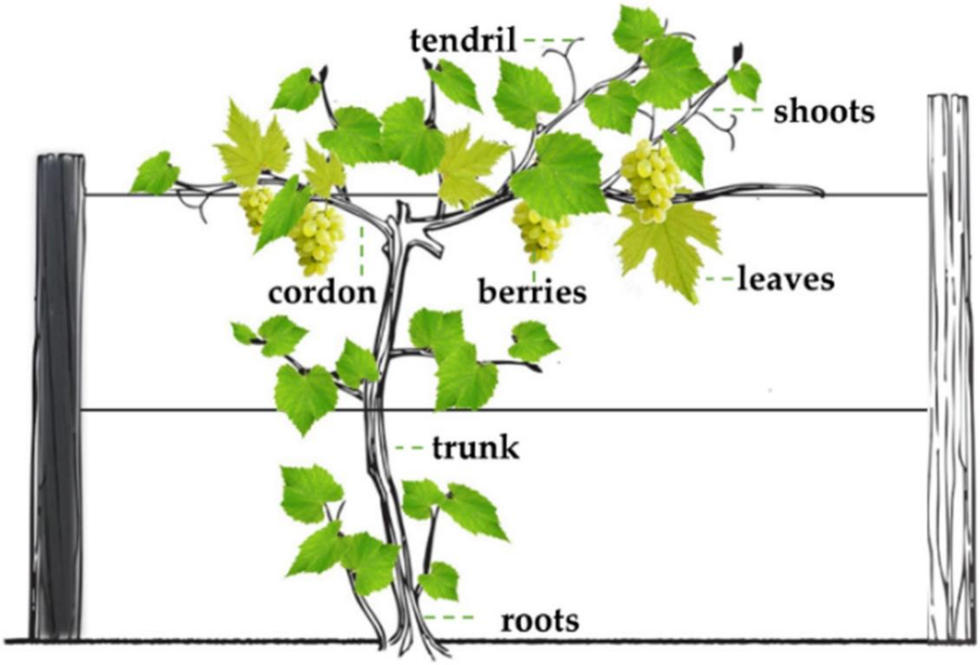


Figure 2. Vegetative parts of grape

Flower

The inflorescence of the grape is a complex raceme. Its flowering usually begins in early June and lasts for 4-5 days. Its flower consists of 5 sepals, 5 petals, 5 stamens, and 2 carpels, a K5 C(5) A5 G(2) upper carpel and 5 nectaries at its base. The flowers are green, only the nectaries are yellow. The grape flower can be classified into three different types based on its sexual characteristics:

· Functionally male (andro-dynamically sterile), in which the stamens are developed, standing at a 45° angle. The pollen is capable of fertilization, but the pistil is underdeveloped, reduced. The flower falls off without fertilization.

· Hermaphroditic (andro-dynamically fertile), in which the stamens and carpels are developed, the flower is functional, self-fertile.

· Functionally female (gyno-dynamically fertile), in which the pistil is developed, but the stamens are undeveloped. The pollen grains do not develop a tube, the fruit can be fertilized by the pollen of the male or the male-specific grape (cross-fertilized), e.g.: Kéknyelő, Bakator, Demjén.

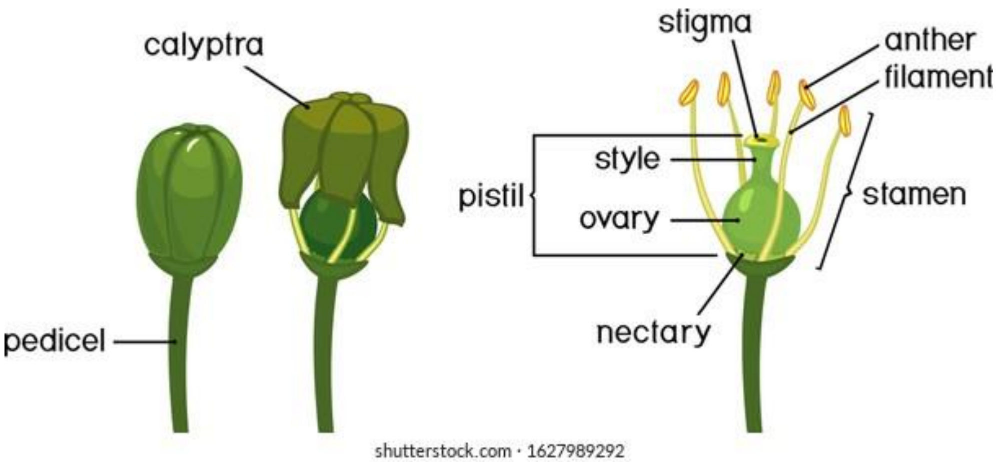
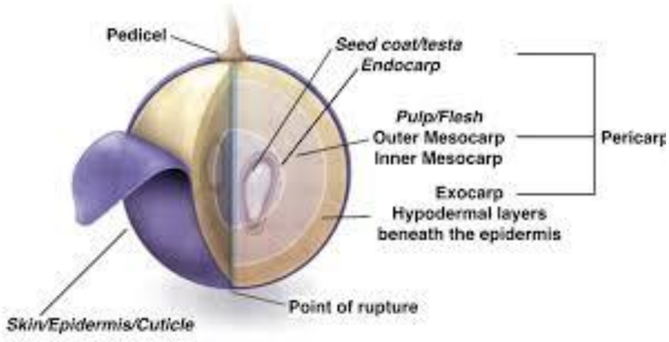


Figure 3. Flower of grape

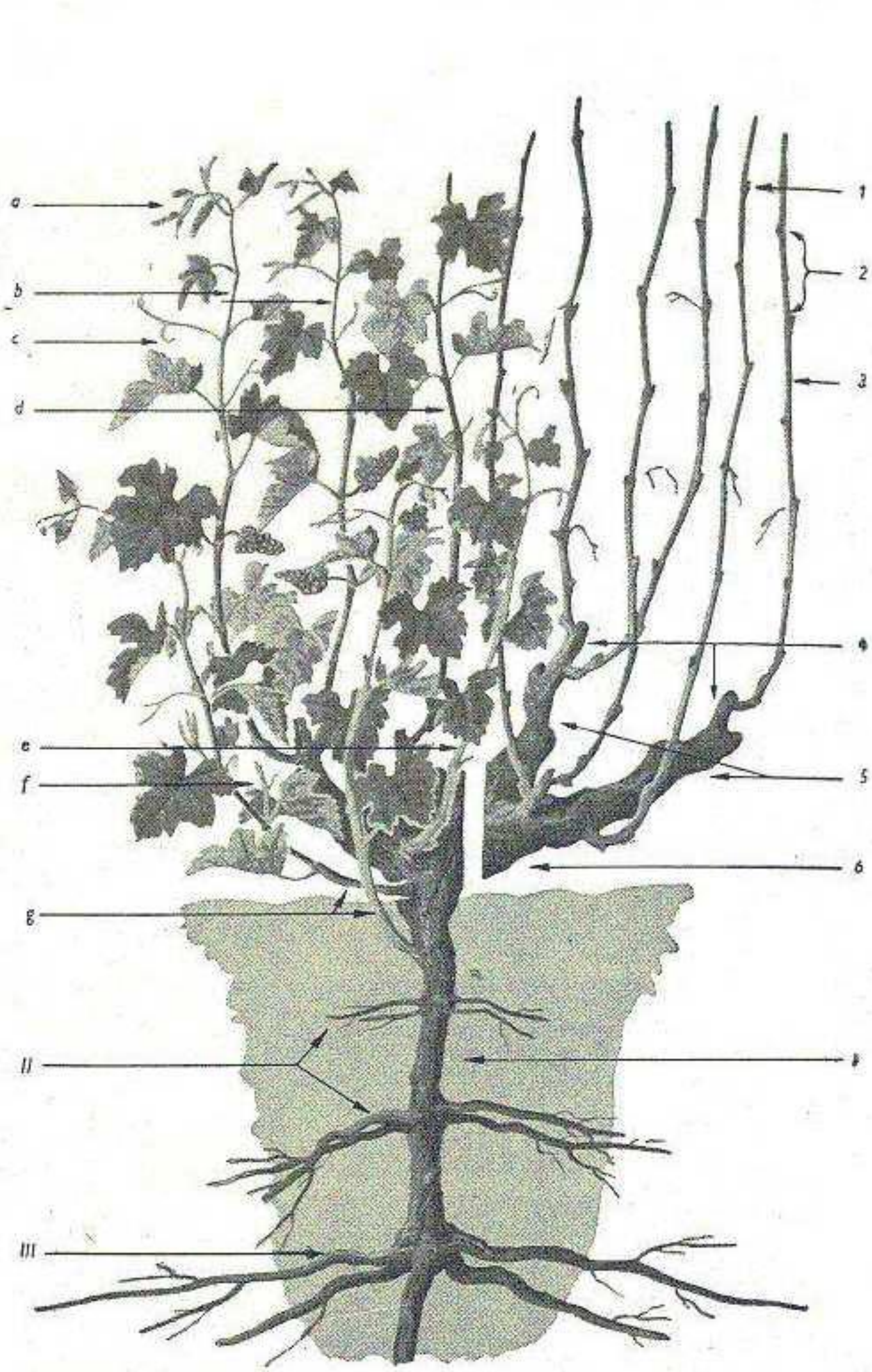
Fruit and the cluster

The fruit of the grape is a berry. The colour of the berries can be yellow, blue, or red. The shape of the ripe berries is varied, and their size also depends on the species and variety. We can discover small, brown dots on the skin of the berries, which are the remains of air spaces that have been continuously filled with moisture during ripening. The berry therefore breathes continuously during ripening, taking in oxygen. The remains of the pistil can be found at the top of the berry.

Seed



The ripe grape seed is 5-8 mm long, round or pear-shaped. Its morphology is divided into two parts: the seed coat and the seed body. The seed coat is the lower, narrowed, pointed end of the seed, and the seed body is the upper, wide part. The size of the seed coat depends on the species and variety. In the case of the wild grape (*Vitis sylvestris*), the seed coat barely protrudes from the seed body, while in the case of the garden grape (*Vitis vinifera*), it bulges out long and clearly. The chalaza is located in the middle of the seed body. The seed body and the seed coat are connected by the umbilical cord (funiculus).



shoot tip, fruiting cane, tendril, renewal spur, sucker cane, neck sprout, lateral cane, branch root, base root,

bud, internode, shoot, spur, short arms, wine head, primary root

Chapter 16

Origine of *Vitis vinifera*

The systems based on the geographical origin of grape varieties were first grouped in 1841. At that time, the grouping according to the ripening time was also taken into account. In 1913, the ampelographer József Gábor classified grape varieties into four groups based on their geographical origin and seed diagnostics. This study was expanded by the botanist József Adrasovszky. In his work, he observed not only the geographical origin, but also the dominant morphological characters, and based on these, he established five independent groups. In 1943, a study was published in Italy that classified dessert and wine grape varieties separately. In 1944, the Hungarian winemaker Dénes Marton published his ampelographic study, in which he classified the varieties into three tribes. He characterized the tribes and listed the varieties within them. A year later, the Moldavian ampelographer Negrul published his work, which classified grape varieties based on their geographical and ecological characteristics. Our note describes this system.

Table 2. Origin of *Vitis vinifera*

Classification	Varieties
western genus (*conv. occidentalis*)	Cabernet saugvignon, Merlot, chardonnay, Pinot-noir, Tramini, Italian rikling, Pinot-gris
central European genus (conv. pontica)	Furmint, Hárslevelű, Sárga muskotály, Kövidinka
eastern genus (conv. orientalis)	Kékfrankos, Afuz-ali, Juhfark, Ottonel-muskotály

Biological role of aboveground parts

shoot tip: transpiration, photosynthesis, type specific

tendril: modificated blossom, climbing

fruiting cane: fruit of this year

renewal spur: fruit of next year

sucker cane: no fruiting, must be cut off!

neck sprout: no fruiting, must be cut off!

lateral cane: no fruiting, must be cut off!

bud: growing of leaves and fruit

cluster: evolution of flowers, ripening of grape

leaf: transpiration, photosynthesis, nutrient storage

internode: distance between two buds on shoot

shoot: transpiration of water and nutrient

spur: growing of shoot

short arms: growing of spur

vine haed (trunk): growing of plant

Biological role of subterranean parts

base root: water and nutrient uptake, sustainment of plant

branch roots: water and nutrient uptake, sucker power of root hair

primary root: transport of water and nutrient, root pressure

Grape photosynthesis (C3)

Grapes absorb carbon dioxide from the air through the gas exchange openings (stomas) of their leaves or through their roots. The average CO_2 concentration in the air is 0.03%. The optimal CO_2 concentration for grape photosynthesis would be 0.3%. Grapes suffer damage above a CO2 concentration of 1%, and are unable to photosynthesize below a CO2 concentration of 0.01%. Grapes use CO_2 to build up the organic acids and carbohydrates that are used in the berries. The harmonious ratio of these determines the quality of the fruit. The intensity of CO_2 uptake by the roots can be increased by incorporating organic fertilizers and compost materials. Leaf CO_2 uptake is greatly influenced by high temperature, low humidity, poor light and water shortage, or diseases and pests that damage the leaves.

Grape respiration

During its respiration, grapes take in oxygen and release carbon dioxide and water. It can take in oxygen through the stomata, the bark and the root hairs, and then deliver it to the cells through the intercellular passages through the cell wall. In the cells, mitochondria obtain energy (ATP) from carbohydrates during biological oxidation. The plant uses this energy to transport nutrients and synthesize new substances. The plants exhale the CO_2 and water that appear as the end products of the process. The intensity of respiration can be increased by periodic soil loosening, appropriate pruning and green work. The oxygen uptake of grapes is greatly influenced by the growth force, the O_2 content of the atmosphere and diseases and pests that damage the leaves.

Photorespiration

The intensity of biological oxidation in green plants decreases in grapes due to the stronger irradiation of sunlight, so the grapes switch to light-induced respiration (photorespiration). Photorespiration is an alternative pathway of photosynthesis, in which a high O_2 content occurs. In this process, amino acids are produced (glycine, serine, alanine), from which CO_2 is released as an end product, then leaves the plant, and of course energy is produced in the form of ATP formation.

Mineral nutrition of grapes

Grapes absorb macronutrients to grow their vegetative parts (root, stem, branches, leaves). These make up about 95% of the plant. For the development of generative parts (inflorescence, seeds), for the activation of enzymes, for fertilization, and for photosynthesis and respiration, they absorb micro- and meso-nutrients. They absorb nutrients predominantly through the roots, but to a lesser extent, the leaves can also absorb essential nutrients.

The essential macronutrients of grapes are C, H, O, N, P, K, S.

The essential micronutrients of grapes are Fe, B, Zn, Cu, Mn.

The essential meso-nutrients of grapes are Ca, Mg.

Chapter 17

Nutrient-supply of grape

Nitrogen (N)

Roots cannot absorb elemental nitrogen from the air. They can only utilize nitrogen in the form of NO_3^- and NH_4^+. Nitrogen is a building block of nucleic acids, proteins and vitamins. It cannot be replaced by other elements. The absorbed nitrogen salts would be converted into organic nitrogen compounds in the plant, which is negatively correlated with carbohydrate metabolism. Therefore, if the N supply increases, the synthesis of carbohydrates in the grapevine organs decreases. The dynamics of nitrogen uptake varies during the annual biological cycle of the grapevine. The N content of the roots is relatively constant. The grapevine has a low N content, which it tries to replace in the autumn. The N demand of the shoot is very high during the vegetation period, and then the N demand of the cane decreases linearly as the dormant period approaches. The foliage of the grapevine has the highest N requirement. This requirement lasts until the dormant period, then towards autumn the nitrogen flows from the leaves to the fruit and the woody parts of the grapevine. About 60% of the total N - amount taken up is realized in the vegetative parts, and 40% is used by the inflorescence.

In case of insufficient N - supply in the soil, the fruit takes nitrogen from the leaves, which leads to early leaf fall. This reduces photosynthesis, which results in a low acid-sugar ratio in the berries. Excessive N-uptake causes distorted growth and stimulates the formation of an unpleasant main taste in the wine.

Phosphorus (P_2O_5)

Grapes absorb phosphorus through their roots in the form of orthophosphoric acid (H3PO4). The absorbed phosphorus is rapidly converted into organic phosphoric acid esters and pyrophosphate compounds. It accumulates most in the actively growing parts of the grape (seeds, flowers, leaves). It is of outstanding importance in protein metabolism, ATP synthesis, enzyme function, and the structure of mitochondrial and chloroplast membranes. In the annual biological cycle of grapes, phosphorus plays a role mainly in the development of generative organs, and is found in significantly smaller quantities in the vegetative parts. Of the vegetative parts, it occurs in the roots to the greatest extent. However, most phosphorus accumulates in the seeds. The P content of shoots is about 20% less than that of leaves. At the beginning of fruit ripening, a significant part of the phosphorus taken up by the roots migrates to the fruit. P deficiency is manifested in the burgundy discoloration of the leaves (anthocyanin formation), incomplete flower formation, and the amorphous formation of berries and the seeds contained therein. Excess P can also manifest itself in nutrient antagonisms (e.g. Zn).

Potassium (K)

Potassium is of particular importance in grape metabolism. The roots absorb it as K^+ ions from soil solutions and then store it in vacuoles and plasma. The presence of K^+ increases the grape's water absorption, enables the flexible opening of stomata, and plays a role in the functioning of enzymes, which cause the biosynthesis of vitamins, sugars, starch and proteins. It increases the frost resistance of the grape. It is an essential element in the process of berry ripening and the formation of sugars. The K- requirement of vegetative parts is primarily manifested in young shoots. In the canes, this is much less. The K-requirement of buds and flowers exceeds that of leaves, but the berry requires potassium the most. So, in the annual biological cycle of grapes, potassium is an essential nutrient in the process of berry ripening. Its deficiency causes the flowers to drop and stunted, tasteless clusters to develop. The leaf margins die. Its excess inhibits the absorption of Mg^{++} and Ca^{++}.

Iron (Fe^{2+})

Grapes can absorb iron in the form of Fe^{2+} or Fe^{3+} ion or iron chelates through their roots. It can be used in the work of respiratory enzymes (catalase, peroxidase, dehydrogenase, cytochromes). Grapes can only use the Fe^{2+} ion in chlorophyll synthesis. Iron is present to the greatest extent in the roots, and is less abundant in the shoots, flowers and twigs. The iron requirement of the leaves, however, is very high, and this requirement gradually increases until the beginning of leaf fall. The iron content of berries is high at the beginning of ripening, then decreases progressively until the ripening period. In the absence of iron, respiratory enzymes are damaged, the leaves turn yellow uniformly (chlorosis), because chlorophyll synthesis is inhibited. The roots thicken, which can result in poor growth of the twigs.

Boron (H3BO3)

The physiological effect of boron is most similar to that of phosphate ions. In dissolved form, it enters the grapevine as borate. Boron plays a role in grape growth, flower and fruit formation, but mostly in fertilization. Therefore, boron is present in low levels in the vegetative organs of the grapevine, with the flowers having the greatest need for boron. Boron regulates the opening of the anthers, and thus the fertilization of the pistil. In its deficiency, fertilization disorders occur, only a few berries develop in the cluster (bird-shaped cluster). The berries are colourless, "lead-shiny". Its deficiency can also be caused by extreme sandy soils and acidic pH (3.5-4).

Zinc (Zn^{2+})

The physiological role of zinc is in grape growth. It is an essential element in the functioning of growth hormones. The stunted growing vine starts to grow vigorously after zinc fertilization. Its translocation is the same as that of nitrogen. Its deficiency is mostly caused by excessive phosphorus fertilization. Then the development of the vegetative parts of the vine slows down or stops. The leaves are formed asymmetrically. Zinc deficiency can also cause the fruit clusters to fall.

Copper (Cu^{2+})

It plays an important role in the photosynthesis of grapes and the formation of chloroplasts. Chloroplasts also contain copper-containing so-called copper proteases, which are the enzymes ascorbic acid oxidase and cytochrome oxidase. All parts of grapes contain small amounts of copper. Its translocation is similar to that of potassium. Its deficiency does not occur very often in Hungary. However, its excess has a toxic effect. It stops the transport of Fe^{2+} ion in the roots, which is why chlorosis occurs.

Manganese (Mn^{2+})

Grapes can utilize manganese in the form of active Mn^{2+} ion. Its function in grapes is exactly the same as that of magnesium. The uptake and translocation of the two elements are identical. Manganese also has a positive effect on the formation of flowers and has a positive effect on the colour and aroma of wines. In case of deficiency, the addition of manganese sulphate in addition to N P K fertilizers have a positive effect.

Calcium (Ca^{2+})

The Ca^{2+} ion taken up by the roots are transported acropetally (from the roots to the shoot tip) to the leaves and fruit by transpiration. Since calcium cannot flow back, it accumulates in the older leaves by the beginning of autumn. In contrast, the Ca^{2+}- content of the roots, vines and shoots is very low. Calcium is present in the plant freely or in sorbed bonds, but Ca-oxalate, Ca-phosphate and Ca-carbonate are present in the vacuoles and cell walls as structure stabilizers. The uptake of Ca^{2+} is inhibited by excessive potassium and magnesium fertilization, in which case Ca deficiency symptoms may appear in the grapes. In grapes grown on volcanic bedrock, a Ca^{2+} deficiency can be ruled out, since these contain sufficient Ca salts. Grapes grown on loess or sand have significantly lower levels of available Ca^{2+}, which results in a lower level of acid production or damage to the grape's acid reserves.

Magnesium (Mg^{2+})

Grapes are sensitive to magnesium supply. It is found in most bedrock, but it often becomes unabsorbable by the grape. The roots can absorb it in the form of Mg2+ ions, then it migrates acropetally through transpiration to young buds and leaves. Magnesium plays a role in chlorophyll formation and cell wall stabilization. It is found in the greatest amount in leaves and berries. Its absorption is inhibited by excessive amounts of potassium and ammonium nitrate. At this time, Mg deficiency symptoms develop in the leaves. The veins of the leaves turn yellow, then die and fall off. Sugar formation in the berries is significantly reduced.

Water requirement of grape

Water uptake

Water has important roles in the life processes of grapes; on the one hand, water is a carrier of nutrients and plant syntheses, and on the other hand, it is a thermoregulator of the plant through evaporation. It is a fundamental building material ensuring the turgor of cells and maintaining their shape. In spring, grapes absorb water with the help of fungal threads (mycorrhizae) surrounding the root hairs, and then it is absorbed by diffusion from the soil's capillary water supply through the older root systems. Transpiration of water reaches the sail in the form of an aqueous solution taken up from the soil. Its speed depends on the species. Transpiration of American grapes is significantly faster (9-12 m/h) than that of Eurasian species (4-6 m/h). The water balance of grapes is significantly determined by the moisture content of the soil and the air. In dry conditions, water loss is high, and the plant protects itself by mechanically controlling the closure of the stomata (stoma resistance). This mechanism allows the grapevine to retain the water necessary for the functioning of its cells. During periods of water shortage, abscisic acid is produced in the grapevine leaves, which regulates stomatal function.

Water release

Grape “shedding tears” (or “bleeding”). The soil temperature (6-8 °C) that initiates sap circulation in spring initiates the process of shedding tears. Active root functions create a more active metabolic process in the cells, faster water uptake, during which the so-called root pressure is formed. This root pressure is the engine of water absorption until transpiration develops. In this period, before bud break, in early spring, water droplets easily emerge from the pruning wounds made on the stem or cane. This provides information to the vine grower that the stem has been well soaked during the winter and that nutrient uptake can begin. If the stem is not soaked, or has frozen during the winter, or if the osmotic potential of the root cells decreases due to salt stress, we cannot induce oozing by pruning. The amount of oozing in a healthy stem is 3-6 liters of liquid. Its dynamics are determined by the weather, the suction power of the roots, the soil temperature and the variety. In the oozing liquid, the grape loses the most calcium, sugar and organic acids.

Transpiration

From the period of spring bud burst and leaf development until autumn dormancy, transpiration is the generator of water transport. Transpiration occurs partly through the cuticles and partly through the stomata. In grapes, transpiration is an active process controlled by stomatal cells, accounting for about 90-95% of total water release. The dynamics of transpiration are determined by the soil moisture content, the root suction power, the loss of turgor of the stomatal cells, temperature and air humidity.

Guttation

Grapes also release water through their leaves in the form of liquid droplets. In humid heat, the transpiration of grape leaves slows down, and water circulation in the plant almost stagnates. Then, water droplets are released from the water gaps at the end of the leaf veins on the surface of the leaf blade due to root pressure. This phenomenon is called guttation, the release of water droplets.

Water stress

The grape root system penetrates very deeply, so the grape's water supply is relatively evenly satisfied. The water requirement of the grape is satisfied by the maximum water content of the soil in most of our crops. If the water content of the soil drops below the water requirement of the grape, this triggers stomatal closure and stress. In the process, the cells gradually lose their turgor, which causes mechanical tension in the cell and then cell death. Due to the increasing dryness, the cell loses a large amount of calcium, but at the same time, potassium is enriched in it, which helps in the conversion of starches into sugars. Sugars have a positive effect on the maintenance of the plasma, so if the water supply of the soil becomes satisfactory again, the plant can still balance out the changes taking place in it. In the absence of a permanent water supply, the size of the berry and the average yield decrease. The plant shows symptoms of nutrient deficiency. Prolonged water stress proves the degree of drought tolerance of grape varieties. The degree of drought tolerance of grapes can be increased with improved rootstocks.

The ecological needs of grapes

For the smooth metabolic processes of the grapevine, it needs a number of ecological factors that influence the life cycle of the grapevine. The optimal provision of physiologically effective environmental factors is mainly reflected in the productivity of the grapevine. These factors are grouped according to the following.

Climatic factors

Light

Grapes are light-loving plants, but during their trunk development, they can also utilize diffused light well, adapting to forest conditions. The absorption of physiologically active light is primarily important in photosynthesis and the metabolism of acids and sugars in berries. Grapes require 450-750 Lux of light. However, sunlight also has harmful effects. After rain, water droplets on the leaves act as a collecting lens and attract the rays to one point, which can cause a scorching effect. The sun's UV-B rays, which the ozone layer cannot absorb and can therefore cause a scorching effect on the tissue structure of grape leaves, are also harmful.

Temperature

Grape (*Vitis vinifera*) is a mesothermal plant, i.e. it can be grown in the temperate zone. In the grape, sap circulation begins at 4-6 °C in mountainous growing areas, and at 10 °C in sandy vineyards. The most favourable temperature for grape growing is an average temperature of 19 °C in July, 21 °C for the production of table wine raw materials, and 24 °C for the production of sparkling wine raw materials. According to some literary data, grapes grow well at an average temperature of 22 °C in Palestine and Egypt, and 25 °C in Pune and Calcutta on the Deccan Plateau in India. However, a decrease in temperature makes the grape resistant, and the potassium balance of the plant may be influential in this.

Air humidity

The most favourable relative humidity for grapes is around 70%. Too high humidity can provide favourable conditions for fungal diseases. Grapes are particularly sensitive to these pathogens.

Air movement, wind

Air movement plays an important role in pollination of flowers. However, it has a detrimental effect on the moisture content of the soil and the plant. Hot summer winds can cause scorching of leaves. In the case of grapes grown on sand wind blows and deflation cause mechanical damage.

Geographical location

The safe limits of grape growing are between 30-50 degrees north of the equator and 20-40 degrees in the southern hemisphere. The northern limit of open-field grape growing in Europe is the Rhine Valley, and in Bolivia, the altitude is 3000 m above sea level.

Soil factors

The edaphic factors of viticulture are based on the mechanical composition, physical properties, chemical and biological characteristics of the soil and bedrock. These can be volcanic bedrock, loess or sand.

Biotic factors

Intensive grape growing and breeding can be endangered by viruses, bacteria, pathogenic fungi, weeds, nematodes, insects and higher animals that damage the biological processes of the grape.

Chapter 18

The life stages and annual biological cycle of the grapevine

The biological development of grapevines is the result of a series of so-called biological cycles that repeat from year to year. The vine lives and produces for many decades. The duration of productivity is naturally influenced by several factors, such as the variety, ecological and edaphic factors, and of course the use of the vine. In Hungary, we can find many 60-80-year-old vines in good condition, but in the Mediterranean areas, 400-year-old vineyards are not uncommon. In most places in our country, grapes are propagated vegetatively due to the phylloxera epidemic, grafted onto an American-type rootstock with some advantageous characteristic. Therefore, in the following chapter, we present the life stages and biological cycle of the vegetatively propagated grape.

Grapevine life periods

After planting, the plant begins to absorb nutrients and transpiration as a result of the strengthening of root functions. As a result, the vegetative parts of the vine begin to develop strongly. We can complete the work phases of vine formation by directional pruning of strong shoot growth. We usually have 4-6 years at our disposal for this.

During the fruiting period, the grapevine, with the help of nutrients and plant hormones, also starts to develop its generative parts, and the flowers and inflorescences begin to form. After the flowers have been fertilized, the plant focuses on fruit formation, the amount and quality of which varies from year to year. This is the stage of increasing fruiting (4-10 years). Its duration can be regulated by professional pruning until the grapevine reaches the stage of full fruit formation. At this time, the vine produces the quantity and quality of fruit characteristic of the species and variety. Our goal is for this stage to last as long as possible.

The full production phase lasts until the vine is 40 years old, after which the vine begins to age.

In the aging phase, in addition to weakened growth and a decrease in biological functions, a decline in yield and crop quality must be expected. Maintaining vine at this stage is no longer profitable, so it is advisable to plough up the plantation and replant it.

Annual biological cycle of grapes

According to many literatures, the vegetative stage of grapes begins with the onset of shedding. However, this phenomenon can only be induced by artificial pruning, so it is not included among the biological characteristics of the annual cycle of grapes. In the next chapter, we will analyse the vital functions that occur without human intervention.

Bud opening

The early spring day when the scale leaves on the buds open and the shoot tip appears is considered the standard. Bud burst occurs within 6-10 days at a daytime temperature of 10 °C. It is advisable to open sand-covered grapes immediately at this temperature to prevent the buds from suffering from so-called bud damage.

Shoot growing

It begins in April at a rapidly increasing rate, reaching its peak at the end of June. At this time, shoots can grow up to 10 cm per day. New leaves develop every 2-3 days. The intensity of shoot growth is primarily a varietal characteristic, but of course the cultivation method and the complete uptake of nutrients (N, K_2O, P_2O_5, Zn^{2+}) are also influencing factors.

Flowering

In the Carpathian Basin (temperate climate), grape flowering begins at the end of May. At an ideal temperature of 20-25 °C and in slightly windy weather, flowering takes place within 10 days. In rainy weather, pollination is delayed, lasting up to 20 days. Grape flowers are wind-pollinated and rarely visited by bees. Pollen retains its fertilizing ability for 4-5 days, while the pistil can fertilize for up to 10-12 days. Only a maximum of 60% of the formed flowers are fertilized, but this allows the shape of the cluster to develop smoothly.

Green growth of berries

The beginning of berry setting is one of the decisive consequences of fertilization. Fertilized flowers begin to ripen berries with a slow but gradually increasing dynamism. Green berries actively respire through the stomata, but this process slows down as they approach ripening, and then the stomata lose their functionality. In the first third of the green growth period, some of the berries turn yellow and fall off, at which time natural cluster cleaning occurs. With this "self-regulating" activity, the grape develops the cluster shape characteristic of the variety. The process ends with cluster closure. During green growth, the tannic acid content in the berries decreases, but sugar is produced in parallel. Sugar is produced continuously for 30-60 days, depending on the variety. The berry skin gradually thins, and a waxy layer forms on its surface. This is called senescence.

Ripening of shoots

The sign of cane ripening is the browning and gradual lignification of the lower part of the shoots. The sugar flowing from the leaves to the shoots is converted into starch and stored. In a well-ripened cane, this is 20% of the dry cane mass. The cane is considered ripe if its color is brown, it breaks when bent, the wood-core ratio is 1:1, the diaphragm is hard, and the water content of the cane is 55-65%.

Fruit ripening

The ripening of berries begins 50-90 days after flowering, depending on the variety. The ripening berry begins to change color. We can observe three phases of ripening. Softening, ripening and over-ripeness. The ripening of the berry occurs when the ratio of acid and sugar produced in it is harmonious. Winemakers call this technological ripening. Upon full ripening, the skin of the berry gradually loses its elasticity, and the berry thus loses water. In the case of table grapes, we are talking about consumption ripeness.

Dormancy

The dormancy period of the grapevine lasts from the fall foliage until the beginning of sap flow in early spring. The dormancy period is marked by a decrease in transpiration and leaf fall after harvest. The flow of nutrients and root functions slow down, but do not cease. Therefore, the period under study cannot be called complete dormancy. When examining the bud dormancy period, three phases can be distinguished.

Conditional dormancy

Characteristic of overwintering buds, long shoot lower buds, sprouted main buds and hidden buds.

Physiological dormancy

The state of buds when they do not sprout for more than 70-75 days, even under favourable conditions.

Forced dormancy phase

Occurs after the deep dormancy state. The buds are already in an active state and will sprout immediately upon favourable environmental conditions (temperature, light, precipitation).

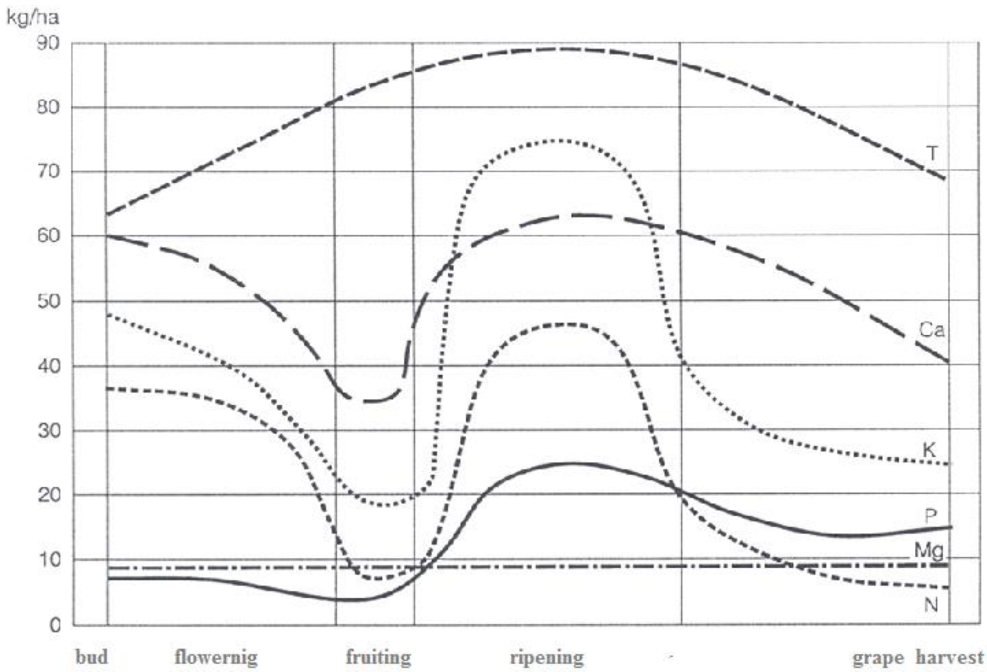


Figure 4. Stages of grape growth

Chapter 19

Choosing the growing location

Grape cultivation is currently taking place in 22 wine regions in Hungary. In order to begin grape planting, the designated land must first belong to a wine region. Planting is regulated by the Wine Act CXXI of 1997 on Viticulture and Wine Management. The law protects the quality of the growing area, determines the volume of production, and allows for financial support. A vineyard exceeding 500 m2 of commercial production may only be established with a permit. The permit is issued by the judge of the given mountain village or the competent local government. If the permit has been received, the following aspects must be taken into account.

Suitability of the grape variety or hybrid in relation to the area,

- area of cultivation of the grapevine,
- suitability of the area to meet the needs of the grape,
- determination of the cultivation system, cultivation method,
- nutrient supply and water supply factors,
- labour and market conditions.

Soil structure, nutrient supply

In our country, grape growing takes place on soil types with different structures and nutrient contents. The phylloxera plague caused grape growing on sandy soils, as the dwarf grape vine cannot reproduce due to the quartz crystals in the sand, and therefore dies. Sandy soils can be classified into 3 groups. Quicksand, weakly humus sand and humus sand. Mostly the soil of the wine regions of the Great Plain.

The yellow sedimentary rock is loess soil. It is the productive soil of the Danube, the Great Plain and some Transdanubian wine regions. The difficult-to-work, reddish clay mineral is the lyrok soil, which covers the Tokaj Foothills and even the Mátra Hills. Its red colour is caused by the presence of iron, potassium and aluminium. In our wine regions on the southern side of Lake Balaton, grapes are grown on so-called Pannonian sand soil. It is ancient marine sediment, which is very rich in calcium. The Pannonian sand of South Balaton is mixed with some loess and clay, and therefore its physical properties are also suitable for grape growing. Among the historical wine regions, wine production takes place on volcanic rocks on the northern side of Lake Balaton, in the Mecsek and the Northern Central Mountains. Bedrock, rich in minerals, gives the wine its characteristic flavour.

Meriolation

(improvement) before planting means increasing the fertility of the soil suitable for planting a vineyard. Meriolation works are carried out 2-3 years before the planting time. Work may include:

Landfilling

In flat rural areas with sandy hills, it means filling in depressions and carrying away hills.

Construction of drainage channels and retaining walls

Technical intervention in hill vineyards. Special ditches and retaining walls in the path of slopes against the destructive work of erosion.

Terracing

A melioration method for steeply sloping (6-30°) hill vineyards. Roads perpendicular to the slope divide the mountainside into sections. Retaining walls or slopes are used on the upper side of the terraces. The disadvantage is that it greatly alters the landscape.

Downhill row guidance

A planting system with a hill-to-valley direction. It allows for a higher vine density and better land utilization than terracing. Grass or other cover crops are also used to prevent erosion.

The supply of nutrients to grapes begins with the autumn application of organic fertilizer (40- 50 t/ha) prior to planting. It must be taken into account that grapes are a long-lived plant, and their roots penetrate deeply into the soil, so nutrients must be applied accordingly. The physical structure and nutrient content of the soil must be treated as a constant factor throughout the life of the grape. Although grapes are not particularly nutrient-demanding plants, they can maintain their condition and productivity by using a steady supply of nutrients. Increased attention must also be paid to eliminating the overdosing of nutrients. Excessive nutrient supply, the so-called "luxury consumption", can hinder the uptake of essential nutrients. In the years prior to planting, soil samples must be taken and analyzed in an accredited soil testing laboratory. The supply of nutrients to grapes is organized based on these. Let's try to use as many natural humus materials and mineral fertilizers as possible.

Table 3. Soil factors for grape planting

Factors	Limit value
soil humus content	more than 0.3 %
topsoil thickness	at least 1 m
groundwater depth	max. 1.5 m
soil pH	5.5-8.8
water-soluble salts	0.15%
basicity	0.06%
$CaCO_3$	max. 30%
soil quartz content	at least 75%

Harvest

The grape harvest is a process that varies from country to country and region to region. The harvest takes place after the grapes have reached biological ripeness. It is not possible to determine the exact date, as ripening occurs at very different times depending on the variety. A wine with a pleasant flavour and rich in acids can be made from well-ripened grapes. That is why we say that the harvest can begin when the acid-sugar ratio in the berries is harmonious and fresh. The harvest can be carried out by hand, by machine, or by combining the two. The harvested clusters are collected in plastic boxes and then placed on the trailer of a tractor driving in the middle of the rows. There are regions where the harvested clusters are collected in containers at the end of the row. In our historical wine regions, grapes were gathered in a basket, and then the harvesters carried them into wooden containers. Today, this tradition can only be found in smaller vineyards, and the harvest has been taken over by mechanization in several of our wine regions. Ampelographer Márton Németh classified the grapes into the following groups based on their ripening time:

- very early ripening (Csaba Gyöngye, Irsai Olivér, Favorit),
- early ripening variety (Chasselas, Kékoportó),
- mid-ripening variety (Othello, Kékfrankos),
- late ripening variety (Merlot, Rhine Riesling),
- very late ripening variety (Afuz-Ali, Italy).

Chapter 20

Plant protection

GSPV grapevine stem pitting virus

GFLV grapevine fanleaf nepovirus

Agrobacterium vitis

Plasmopara viticola,

Eutypa lata,

Botrytis cinerea,

Uncinula necator,

Pseudopezicula tracheiphila

Xiphinema index

Viteus vitifolii

Eriophyes vitis

Lobesia botrana

Sparganothis pilleriana

Viteus vitifolii Fitch. **Phylloxera**

The phylloxera plague was a milestone in the development and transformation of European viticulture and winemaking. It is true that there are many pests of grapes worldwide, but we still need to go into detail about the grape root cap. It came to Europe from America and destroyed 2/3 of the grapes in Europe in about thirty years. The grape root cap, known as phylloxera, was first detected in Europe by French winegrowers in 1863. Since its damage, biology and morphology were unknown to the farmers, it seemed almost impossible to control it. Initially, large quantities of copper and sulphur-based pesticides were sprayed on the grape leaves, but it proved ineffective, as the pest also destroyed the grape roots. At that time, flooding technology was developed, which involved flooding the vines with large amounts of water, with the aim of drowning the phylloxera under anaerobic conditions. Unfortunately, this did not provide a solution either.

In Hungary, the damage caused by phylloxera was first noticed in Pancsova in 1875. The root rot destroyed half of the grape production in Hungary at that time. As a solution, planting was carried out on sandy soils, since phylloxera cannot reproduce in the quartz medium. That is why sandy soils are called "immune soils" in viticulture. At that time, sandy areas, which had previously been considered worthless, could be sold at a very high price. Peach trees were planted in the areas of the vineyards with bound soil, located in the south. Hungarian grape growing and winemaking were concentrated on sandy vineyards. The number of sandy vineyards and wineries increased rapidly in the Great Plain (Izsák, Kecskemét, Csongrád).

However, the final and most favourable solution was developed by Otto Herman, based on the theory that a European noble grape should be grafted onto the American direct-fruiting rootstock, thus preventing the generational change of phylloxera, thereby destroying the pest. Since the complete generational change of phylloxera occurs only on American-type grapes, while phylloxera is destroyed on the leaves of European grapes, only the root-dwelling generations change, based on this, the European noble grape on the American rootstock can be grown with complete safety. The idea proved to be perfect, and this procedure has been used in Europe since then. In Hungary, grape growing was able to return to the mountainous regions, of course, the sandy slopes did not disappear either. They retained their characteristics and history, with which they gained recognition in many countries.

Phylloxera is a root rot that produces several generations. During its development, we distinguish between leaf and root-dwelling generations. This development cycle is completed in 2 years on American-type grapes. The pest overwinters as eggs in the bark cracks of the vine. The sucking mouthpart larvae hatch from mid-May, then inject poison into the grape cells with their sucking action, thereby killing the foliage. In the meantime, the queen forms a ball on the leaf surface and then lays her eggs by sexual reproduction. This involves the creation of at least 4 generations. The generations that have been created since mid-summer already move to the roots. Here too, the queen reproduces by sexual reproduction and lays her eggs. The hatched root-dwelling larvae develop into winged nymphs along the plant roots and then come to the surface in search of sunlight. Here, after several moults, they become winged adults. These winged forms reach several stems with the help of the wind, where they lay new eggs on the undersides of the leaves by sexual reproduction, from which male and female individuals develop. These individuals are wingless. After hatching, they mate, and the fertilized females then lay their winter eggs in the crevices of the stem. This process completes the 2-year development cycle.

Planting plan

(practical task for students)

The planting plan is a credible document that must contain,

- the location, location, topographic number of the plantation,
- soil documentation (soil type, soil structure, groundwater, etc.),
- the process of implementing nutrient supply,
- variety selection,
- the process of planting,
- the method of cultivation, and the harvest-plan.

* * * Students prepare the planting plan in top view, to scale, in A3 size. The above-mentioned factors are submitted along with the floor plan based on their own ideas.

Literature

Andrasovszky I.: Kertészek kézikönyve. Mezıgazdasági Kiadó, 1961.

Angeli L.: Kertészeti ismeretek. Mezıgazdasági Kiadó, 1960.

Bauer K.: Integrierten Weinbau. Österreichischer Agrarverlag, Klosternueburg, 1966.

Bodnár S.: Növényvédelmi állattan. Mezıgazdasági Kiadó, 1979.

Bognár K.: Szılısgazdák könyve. Agricola Kiadó, 1990.

Bognár-Mercz.: Szılımővelés, borkészítés. Mezıgazda Kiadó, 1995.

Bényei F.-Lırincz A.-Sz. Nagy L.: Szılıtermesztés. Mezıgazda Kiadó, 1999.

Bényei-Lırincz.: Borszılıfajták, csemegeszılı fajták és alanyok. Mezıgazda Kiadó, 2005.

Buzás I.: Segédlet a talajtermékenység megóvásának helyes gyakorlatához. FVM Képzési és Szaktanácsadási Intézet Budapest, 2006.

Cseke G.: Színanyagok és polifenolok hatása a borok antioxidáns tulajdonságára. KEÉ. Budapest, 2002.

Cselıtei L.: Kertészet. Mezıgazda Kiadó, 1993.

Csepregi P.: A szılı metszése, fitotechnikai mőveletei. Mezıgazda Kiadó, 1982.

Dimény J.-Helyes L.-Varga Gy.-Kassai T.: Öntözés a kertészeti termesztésben. SZIE Gödöllı, 2003.

Glits M.-Folk Gy.: Kertészeti növénykórtan. Mezıgazda Kiadó, 2000.

Gráf J.: Környezetkíméló gazdálkodás. FVM. Agrár és Vidékfejlesztési Fıosztály kiadványa Budapest, 2009.

Hajdu E.: Magyar szılıfajták. Mezıgazda Kiadó, 2003.

Hajdu E.–Ésik A.: Magyar szılıfajták. Mezıgazda Kiadó, 2001.

Kozma P.: Szılıtermesztés I. Akadémiai Kiadó, 1991.

Kriszten Gy.: Tavasztól tavaszig a szılıben. Mezıgazda Kiadó, 2007.

Lucskai A.: Az ökológiai gazdálkodás. FVM. Képzési és Szaktanácsadási Intézet Budapest, 2006.

Lugasi A.: A vörösborok feltételezett preventív hatása. OÉTI Budapest, 2009.

Németh M.: Ampelográfiai album. Mezıgazdasági Kiadó, 1975.

Némethy M.: Jót tesz-e a vörösbor. Vas Népe, 2007. 03. 01. szám.

Radics L.: Ökológiai gazdálkodás. Szaktudás Kiadó Ház, 2002. pp.410-425.

Szıke L.: Bioszılı, biobor. Mezıgazda Kiadó, 2004.
Tanács L.: Élelmiszer-ipari anyagismeret. Szaktudás Kiadó Ház, 2005.
Tanács L.: Borászat. Fıiskolai jegyzet. Hódmezıvásárhely, 2009.
Walg O.: Taschenbuch der Weibautechnik . Mainz Fachverlag Fraund, 2000.
Zanathy G.: Biodinamikus szılıtermesztés a gyakorlatban. Agrofórum, 20. évfolyam 6.szám 2009 június.
www. szılı lap. hu 2009
www. wikipedia free enciklopedia.hu 2009.
Terry, Leon (2011). Health-Promoting Properties of Fruits and Vegetables. CABI. pp. 2–4. ISBN 978
"What Is Crop Rotation?". WorldAtlas. 25 April 2017. Retrieved 25 January 2019.-1-84593-529-0
Needham, Joseph (1984). Science and Civilization in China 6-2. p. 150.
Lantos F. (2018): Capsicum genus. Book. Szegedi Tudományegyetem Mezőgazdasági Kar.
Lienhard, John (2023). "No. 26: Three-Field Crop Rotatio". The Engines of Our Ingenuity. University of Houston Retrieved 31 December 2023.
Adrasovszky I.: Kerteszek kezikonyve. Mezıgazdasagi Kiado Budapest, 1961.
Angeli L.: Kerteszeti ismeretek. Mezıgazdasagi Kiado Budapest, 1960.
Balazs S.: A zoldseghajtatas kezikonyve. Mezıgazda Kiado Budapest, 2000.
Balazs-Filius: Zoldsegtermesztes a hazikertben. Mezıgazdasagi Kiado Budapest, 1977.
Bognar-Huzian: Novenyvedelmi allattan. Mezıgazdasagi Kiado Budapest, 1979.
Buzas I.: Segedlet a talajtermekenyseg megovasanak helyes gyakorlatahoz. FVM Kepzesi es Szaktanacsadasi Intezet Budapest, 2006.
Cselıtei-Nyujto-Csaky: Kerteszet. Mezıgazda Kiado, 1993.
Cselıtei L. - Helyes L. (1988): The possibility of determining irrigation requirements by means of plant temperature. Acta Horticulturae 220, January, 353-358.p.
Dimeny- Helyes- Varga- Kassai: Ontozes a kerteszeti termesztesben. SZIE Godollı, 2003.
Gordon: Encyclopedie of food science and nutrition. Academic Prest London, 1993.
Farkas-Nagy: A csemegekukorica termesztese I. Kerteszet es Szıleszet, 2007. 56. evf. 17. szam.

Fodor F.: A Duna-Tisza kozi homokhatsag delkeleti reszenek paraszti gazdalkodasa a 20. szazadban. Mora Ferenc Muzeum Szeged, 2008.
Glits-Folk: Kerteszeti novenykortan. Mezıgazda Kiado Budapest, 2000.
Hajosne Novak M.: Kerteszeti novenyek nemesitesenek alapjai. SZIE Godollı, 2007.
Helyes L.: A zoldsegnovenyek vizellatottsaganak jellemzese a lombhımerseklettel. Kertgazdasag, 21. evf. 1. sz. 46-52. p. 1989.
Helyes L.: Relations among the water supply, foliage temperature and the yield of tomato. Acta Horticulturae 227, 115-121.p. 1990.
Helyes L.: A paradicsom termesztese. SYCA Kiado, 1999.
Helyes L.: Az ontozes altalanos kerdesei. Egyetemi jegyzet SZIE MKK. Levelezı kepzes Godollı, 60 p. 2003.
Hodosy- Milotai- Sicz: Az uborka termesztese. Pannonmag Gazdasagi Tarsasag Kecskemet, 1988.
J. Rod et, al: A zoldsegfelek betegsegei es kartevıi. Biocont Laboratory Brno Slovakia, 2005.
Magyar-Petranyi: A belgyogyaszat alapvonalai. Medicinia Kiado Budapest, 1977.
Metlickij. L.V: A gyumolcsok es a zoldsegfelek biokemiaja. Mezıgazdasagi Kiado Budapest, 1975.
Mod L.: A bolgarkerteszek megjelenese Szentes kornyeken. Muzeumi Kiadvany Szentes, 2004.
Nadasy-Almadi: Novenyvedıszer-kemia. Pannon Agrartudomanyi Egyetem Keszthely, 1996.
Nagy J: A sarga- es gorogdinnye. Szaktudas Kiado Budapest, 2005.
Radics L.: Okologiai gazdalkodas II. Szaktudas Kiadohaz Budapest, 2002.
Reader's Digest: Gyogyito etelek-artalmas etelek. Budapest, 2004.
Rigo - Lezak: Klinikai dietetika. OTE Budapest, 1992.
Ombodi A.: Intenziv zoldsegtermesztes. SZIE Godollı, 2006.
Szalai I.: Novenyelettan I-II. Tankonyvkiado Budapest, 1974.
98
Tanacs L.: Elelmiszer-ipari nyersanyagismeret. Szaktudas Kiado Haz. Budapest, 2005.
Tanacs-Szabone: Mezıgazdasagi anyagismeret. EFK Szeged, 1990.
Slezak-Terbe: Talaj nelkuli zoldseghajtatas. Mezıgazda Kiado Budapest, 2008.

Zatyko-Markus: Etkezesi es főszerpaprika termesztese. Mezıgazda Kiado Budapest, 2006.

Wolff E: Gyakorlati tragyazastan. MTA. Talajtani es Agrokemiai Kutatointezete

Terry, Leon (2011). Health-Promoting Properties of Fruits and Vegetables. CABI. pp. 2–4. ISBN 978

"What Is Crop Rotation?". WorldAtlas. 25 April 2017. Retrieved 25 January 2019.-1-84593-529-0

Needham, Joseph (1984). Science and Civilization in China 6-2. p. 150.

Lantos F. (2018): Capsicum genus. Book. Szegedi Tudományegyetem Mezőgazdasági Kar.

Lienhard, John (2023). "No. 26: Three-Field Crop Rotatio". The Engines of Our Ingenuity. University of Houston Retrieved 31 December 2023.