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Advanced fruit growing

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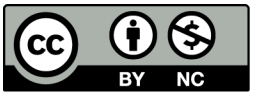

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ADVANCED FRUIT GROWING

Contents

ORIGIN OF FRUIT SPECIES

Knowing the origin of fruit trees that are grown in our latitudes, in addition to the general perspective, also helps to better understand the fruit grower in some growing problems. Most fruit species have gone a long way in developing and evolving into the form we know them today. We find the origin of fruit trees in three centers on the Asian continent.

The first center of origin is located in the Transcaucasian region of Asia, the Persian Gulf and present-day Turkmenistan. From this area, apples, pears, quinces, plums, cherries, apricots, walnuts and almonds have come to us from the past. They gradually evolved and adapted to our conditions. Some have managed to adapt to the changed climatic conditions, others do not yet, as a result of which there are also some problems in cultivation. It is e.g. susceptibility of apricot flowers to frost, resp. their flowering at a time when spring frosts are still threatening. In Europe, the longest-grown are pome fruits, especially apples and pears and are the ones that have adapted to the changed environmental conditions, and the local climate will not cause them significant damage. A little later, apricots and almonds, which have not yet fully adapted to the conditions of Central Europe, began to penetrate the Central European region.

Apple trees probably spread to us from the Transcaucasian region, eastern Turkey and southern Russia. There are assumptions that the species of apple tree as we know it today was formed from eight different species. Most, in an unaltered genetic structure, can be found in the original territory of the Caucasus region, which also serves as a gene center for breeding needs.

Pears can be divided into two groups: European pears (*Pyrus communis*) and Asian pears (*Pyrus pyrifolia* and *ussuriensis*). It is believed that *Pyrus communis* in particular contributed to the formation of European pears, but it was not found in nature and was probably caused by a cross between *P. caucasia* and *P. nivalis*. The original area of occurrence is mapped in the Caucasus (Eastern Europe) and Asia, but also in the Mediterranean. Central and South China are mentioned as the centers of origin of Asian pears (also known as Chinese, Japanese, Oriental, nashi).

Quince and its exact origin are not completely known, but wild individuals are found in the wild only in some parts of Asia, specifically in Armenia, Azerbaijan, Georgia, Turkmenistan, Iran and Saudi Arabia.

Apricots come from one of the original species *Armeniaca vulgaris, son. Prunus armeniaca* originating in the area of northeastern China and southern Russia and not in the area of present-day Armenia, as the Latin name suggests. From there, they spread very slowly to central China, Armenia and later to Europe.

Plums probably came to us from the area of western (front) Asia, from the Caucasus Mountains and the adjacent Caspian Sea area. Genetic analyzes show that they evolved from the species *Prunus domestica*, which was not found in nature. It has been hypothesized that this species was created by random crossing between *Prunus spinosa* (blackthorn) and *P. cerasifera* (myrobalan).

Cherries also evolved from the wild species *Cerassus (Prunus) avium* in the Caucasus region, more precisely between the Black and Caspian Seas.

Almonds and its relatives originate in an area close to the climate of the Mediterranean region, more precisely the territory of present-day Pakistan and the eastern part of Syria and Turkey. Almonds and its close relative peach probably evolved from common ancestors in Central South Asia. The different path of development between almond and peach was probably due to the formation of the mountains of South Asia millions of years ago. Subsequent differing climatic conditions allowed almonds to spread and adapt to drier western areas, while peach spread to the more humid eastern parts of central south China.

Mountain ash and its origins are thought to be in the areas of southern and Eastern Europe, from where it has spread and domesticated almost throughout Europe. Some sources also cite Britain, Ireland and North Africa.

Walnut and its homeland must be found in Eastern Europe, Asia and the original occurrence of *J. regia* is also found east of the Himalayas, although the natural occurrence of *Juglans* is also found in North, Central and South America, Europe and Asia. Although Europe is considered to be the original homeland, this domestication was probably preceded by imports from Persia.

The second center of origin from which fruit trees spread to Europe is the Mediterranean region. This is where the representatives of small fruits come from, such as raspberries, blackberries, gooseberries, currants, but also hazelnuts. However, this is probably the area of secondary distribution of these species, which were introduced mainly by Romans and Greeks.

Gooseberries originally come from two species – *Ribes grossularia*, referred to as European gooseberries. The origin has been documented in the Caucasus Mountains and North Africa. The second species was *R. hirtellum*, known as the American gooseberry, native to the northeastern and northwestern regions of present-day the United States and adjacent parts of Canada. *Grossularia reclinata,* which grows wild in Europe, Southwest Asia and North America, is also considered to be another genetic source of today's gooseberry varieties.

Currants and their origin can be found in the higher altitudes of the wider area of the northern hemisphere. Native botanical species are found in Europe, Asia and North America.

Raspberries have developed in Asia and North America, with many sources mentioning Mt. Ida in the Caucasus as the origin of red-fruited raspberries. The homeland of black raspberries is described exclusively by North America, especially its eastern coast around the Gulf of Mexico, but also the coast in the west.

Blackberries and their origins are documented in Asia, Europe, North and South America, and later domesticated in Southeast Australia.

Hazelnut and its current cultural varieties originate in Europe and Asia Minor, where it prefers areas with mild, humid winters and colder summer months.

The third center of origin is located in the area of China, where the oldest culturally used fruit peach comes from. The original home of the ecotypes from which peaches evolved is the south of China, from where they came to Persia (Iran) with the help of silk merchants. From this area, which is incorrectly considered their original homeland, the peaches were later brought to Europe by the Greeks, but especially by the Romans.

INTENSIFICATION OF FRUIT GROWING

After 1989 and subsequently after Slovakia's accession to the EU, we were and still are confronted with demands to increase the quality and quantity of fruit including reduction of production costs. After the opening of the borders, the market also spread and thus the Slovak fruit found itself in a huge competitive environment, which did not tolerate low-quality fruits. For this reason, the entire fruit production had to start transforming and adapting to the new competitive environment in order to increase production and quality while reducing overall production costs – the process of intensifying fruit production began, which changed the approach to cultivation and production from the ground up.

Extensive fruit production systems

The term extensive fruit growing systems means all those growing systems in past and present, for which there is no primary requirement for the highest possible fruit quality and quantity. In the past, there were only such systems for several reasons, mainly due to the absence of week-growing rootstocks, which did not allow dense plantings, so the trees were too tall to have control over them in terms of pruning and training, protection, harvesting, etc. , which of course affected the quality of the fruit. The fact that fewer trees could be planted per unit area also affected the quantity of the crop. The primary feature of extensive systems is the low specific yield per unit area (ha, m^2, m^3) compared to intensive systems. They are also characterized by taller growing trees. These include high-stem, half-stem and in some cases, quarter-stem also, which are in form of height and production intensity some transient forms between extensive and intensive systems. Another feature is fewer trees per hectare, which is given by the growth intensity influenced by rootstock. The stronger the growth, the taller and wider the tree, the fewer trees per ha can be planted. It is logical that for taller and wider trees, the spacing also changed depending on these parameters. On the other hand, when we look at the yield per tree, it is significantly higher in extensive systems compared to intensive systems depending on the shape and spacing. The taller the tree, the higher the crop. However, this does not apply to the total harvest per ha, and here it is true that the taller the tree, resp. shape, the lower the total yield per ha (or specific yield). Therefore, we achieve the lowest yields per ha at high-stems.

Tab. 1. Comparison of growing and yield parameters in dependence to stem height.

Shape	spacing (m)	number of trees (pcs/ha)	tree height (m)	yield (kg/tree)	yield (t/ha)
HiS	8 – 10x10 – 20	50 – 100	8 – 12	100	5 – 10
HaS	8 – 12x6 – 10	100 – 200	6 – 8	80	8 – 20
QS	6 – 8x5 – 6	200 – 400	4 – 6	60	12 – 24
D	3 – 4x5 – 6	400 – 800	2 – 4	40	16 – 32
S	0,8 – 1,2x3 – 3,5	1000 – 4000	2 – 2,5	15 – 20	40 – 80

HiS – high-stem, HaS – half-stem, QS – quarter-stem, D – dwarf-stem, S – spindle

Similar trend is also in the quality of the crop, which is currently crucial. With higher stem-forming trees, the proportion of quality fruit is very low, in some cases it may not even reach 10%. This is given by the size and volume of the crown. The larger the crown volume, the less quality fruits we get. This is related to the fact that within the crown are the best fruits on the perimeter and on the top of the crown. The fruits from inside the crown are often unsatisfactory in size, undeveloped and uncolored, and the paradox is that because of the tree height, harvesting from the highest parts is practically impossible. It is similar in terms of sales. The bigger the tree, sales are lower.

Tab. 2. Comparison of yielding parameters in dependence to stem-height.

Tvar	Yield (kg/tree)	Yield (t/ha)	share of extra class (%)	yield of extra class (t/ha)	sales of extra class (EUR/ha)*
HiS	100	5 – 10	10 – 20	0,5 – 1	250 – 500
HaS	80	8 – 20	20 – 30	1,6 – 6	800 – 3000
QS	60	12 – 24	30 – 50	3,6 – 12	1800 – 6000
D	40	16 – 32	50 – 80	8 – 25	4000 – 12500
S	15 – 20	40 – 80	90 – 100	36 – 80	18000 – 40000

HiS – high-stem, HaS – half-stem, QS – quarter-stem, D – dwarf-stem, S – spindle
*- price of 1kg apples as 0,50,-EUR

In terms of pruning and training is pruning larger and taller trees more difficult, ladders or platforms are necessary, but it is almost impossible to reach to all parts of the crown, especially to the highest parts. Pruning such trees is also time-consuming. From the current point of view, it is highly uneconomical.

It is similar in terms of protection against diseases and pests. In the past, an application technique was used that was inefficient, with low pressure, large drops, so the spray did not reach the highest parts of the tree, which remained untreated. Consumption of plant protection products also increased in line with the size of the crown, and at the same time there was a high pesticide outlet. In the past, used chemical substances have often been ineffective. Overall, this has again led to economic disadvantage.

It was similar also by the harvest. It was a very time-demanding process, again unthinkable without ladders or platforms, despite the use of special equipment, harvesting from the highest parts of the crown, where the fruits were of the highest quality, impossible. Harvesting has been done multiple times, which is also disadvantageous. The larger the crown, the more uneven the fruit ripens. First, the fruits from the perimeter and from the highest parts of the crown were harvested, then it was waited for the others to ripen, so that the cost of the harvest itself, resp. workers' wages were higher, not to mention that mechanization had to be added to the orchard each time, and by such frequent passes the soil was degraded by compaction. There were also higher expenses when sorting fruits, because in most trees there was no quality regulation and the fruits were out of shape, size and color. Another disadvantage was that the fruits could not be stored at once, which subsequently reduced their storability, so there were relatively large losses, respectively. The fruit was a scarce commodity in the spring.

The yield quality and quantity was low, the fruits were unevenly large and unevenly colored and inconsistent in shape. There was no crop regulation in the form of fruit thinning; the trees were affected by alternate bearing, so often the harvest was done only every 2 years. The varietal assortment was outdated from today's point of view, the age of orchards and trees was calculated for decades and it was difficult to respond to market requirements from a varietal point of view, because the removal of such trees was very difficult, not to mention that entry into fertility by newly planted tree was very late, often 5 – 8 years.
Special procedures absented, pruning of the trees was uniform, often regardless of variety or even species. Systems of summer cuts were not present, flower- and fruit thinning also were absent, there was little or no agrotechnics, resp. soil care in row and between the rows. In many plantings, additional irrigation was absent or made by logging, which led to the formation of drought-spell and the spread of fungal diseases in particular, not to mention water waste. Signaling and prognosis systems were not used to protect against diseases and pests. There were also shortcomings in terms of marketing, logistics and overall fruit sales.

Intensive fruit production systems

Intensive cultivation systems can be characterized as current. Their common denominator is the higher specific yield per unit area. We also partially include some plantations of quarter-stems here, but only very rarely. Intensive systems include dwarf-stems and especially spindles. The difference is in the architecture of the crown and tree spacing. The total height of the mentioned shapes can be approximately the same, from 2.5 to 3.5 m; the differences are in the width of the trees. While the width of a dwarf-stem tree corresponds approximately to its height, the width of a spindle tree is different. The most common width of the tree in the current intensive plantings is approximately 1 m, but widths of 0.6 – 0.8 m are not uncommon. The width between the rows is most often 3.5 m.

As a result, the dwarf-stems are planted in spacing 5 – 6 x3 – 4m, while 0.8 – 1.2x3.5 for the spindles, which is reflected in the different number of trees per ha (dwarf-stem 400 – 800pcs/ha, spindles 1000-4000 pcs/ha). Crop yields are adequate for this. While we can count on approx. 30 – 60 t/ha for dwarf-stems, the yields for spindles range from 40 to 100 t/ha. It is also similar with the quality of the fruit. Due to the absolute control of the tree (80% of all work can be done from the ground) we often achieve 100% quality fruit from the spindles. Overall, yields are higher and more stable.

State-of-the-art knowledge is used in pruning and training systems, however, pruning is relatively simple and it is related to the simplicity of the shape itself, whether the dwarf-stem, but especially the spindle. By pruning it is possible to treat all parts of the trees, including the tallest parts whereby 80 – 100% of the work can be done from the ground. In terms of time allocation for one tree, modern shapes are also very economical; one tree can be pruned in a few minutes in some cases, which is very economical.

Fig. 1. A modern and simple intensive apple orchard. (photo: Mezey)

Protection against diseases and pests is also much simpler, better and more economical than in the extensive systems. It is possible to easily treat the entire tree without the need for complicated systems; it uses a powerful application technique with high-quality dispersion of sprays. At the same time, there are a number of special sprayers for individual cultures on the market. There is lower pesticide consumption and outlet. Spraying technology has high efficiency and quality.

Fig. 2. Spraying technique in intensive orchards. (photo: Mezey)

Fruit harvest is a time-saving process in terms of efficiency. With well-grown trees, one worker is able to harvest 150 – 180 kg of fruit per hour (apples, pears), the worker is only engaged in harvesting, he does not have to carry ladders, if a platform is used and its speed varies depending on the harvesting speed. Efficient collection systems also can be used, e.g. Pluck-O-Track, which further increases employee performance. Unlike extensive systems, harvesting from the highest parts of the tree is possible. Harvesting can be done in one, maximum two times, lower fuel costs, lower labor costs and lower soil compaction. Sorting fruits is less expensive, as the fruits are almost the same in shape, color and size. The main advantage of harvesting is that it is then possible to store all the fruit at once, the cooling chamber can be closed very soon after storage and set a suitable atmosphere in it. This method does not result in higher storage losses and the fruit can be stored for a very long time.

In intensive growing systems, the quality and quantity of the crop is very high, the fruits are evenly sized (thinning) and evenly colored (thinning and summer pruning). We obtain quality fruits from all parts of the crown. Compared to extensive planting, the yield per tree is lower, but when calculated per hectare, the yields are much higher and, most importantly, there is a large number of a fruit in extra quality (80 – 100%). With spindles, we practically or naturally do not encounter alternate bearing, nevertheless, it is highly recommended to do either chemical flower thinning or fruit thinning respectively.

Fig. 3. So called train-picking system by the harvest. (photo: Mezey)

Overall, the trees are lower, but they enter bearing very early, some types of trees reach flowers already in the fruit nursery. However, the lifespan of such trees is lower, with intensive spindles it is at the level of 12 – 15 years, after this time it is necessary to remove the trees, which entails costs. On the other hand, it is possible to change the varietal assortment very quickly and thus respond to the specific needs of the market in terms of varieties.

Intensive systems are also characterized by the fact that the cut is made on the basis of species requirements, variety, habitat conditions and crop height. Most plantings require a summer cut, which brings higher costs, but which are offset by higher fruit quality, similar to the need for harvesting. Optimal agro-soil treatment techniques are carried out, which are also higher costs. Nowadays, additional irrigation is necessary, which increases the total cost, but without additional irrigation, we do not recommend establishing and operating an intensive orchard. It is slowly becoming necessary to build a retention water reservoir, into which we collect water, whether from the roofs of buildings, warehouses, halls or wells. Intensive plantings also include well-thought-out nutrition and fertilization systems based on soil, leaf and fruit analyzes. Unfortunately, antifreeze measures are also becoming a necessity, of which antifreeze irrigation appears to be the most effective.

The method of burning paraffin candles, which are scattered by helicopters, is also relatively effective. In protection against diseases and pests, we use signaling and prognosis systems, which are conditioned by the presence of an automatic meteorological station with the appropriate software program on the basis of which it is possible to apply sprays in a very targeted manner. All these measures bring increased costs, but in the end it will have a very positive effect on the overall economic situation of the company. Last but not least, the producer has the opportunity to request support while meeting specific requirements, both from national and European sources.

ECOLOGICAL FRUIT PRODUCTION

Organic farming is agriculture that is based on the principles of the return of the traditional way of tillage and agricultural production based on the exclusion of harmful inputs of the chemical industry, such as fertilizers, pesticides, herbicides, fungicides and others. Preferred field crop rotation practices are preferred as natural crop protection against pests and diseases, and soil fertility is restored through the use of organic fertilizers from livestock. The products of such agricultural production are marked with the organic product label.
For organic farming, the ecological harmlessness of production, respect for the natural biodiversity of the country, the production of health-friendly food for the population and fodder for livestock are paramount.

Why bio?
1. Health principle – sustainability and improvement of soil, plant, animal and human health
2. Ecological principle – built on the foundations of living ecosystems and their cycles, with which it is necessary to cooperate, imitate them and help sustain in the long run
3. The principle of care – ensuring a responsible approach to the protection of the health and comfort of present and future generations
4. The principle of respect – built on ensuring respect for nature and the environment

There is a huge demand for organic products within the EU and the consumption of organic products is constantly rising. Over the last 10 years, the area has increased by 70%. Currently, 7.5% of the total area of agricultural land is in the organic regime, while the total area of agricultural land is 13.4 million ha. The structure of organic production in Europe consists of arable land, including vegetables and cereals, permanent grassland, mainly as pastures and meadows (mainly for R&D) and permanent crops (fruit and olives). Organic farms are on average 2 times larger than conventional, but the yields are at the level of 40 – 85% of the yield from conventional production, while the prices of organic products are 150% higher.
Of the total area, 56% in the EU are concentrated in 4 countries: Spain (16%), France (15%), Italy (14%) and Germany (11%). Spain has the largest acreage and Austria the highest % share of acreage of agricultural land. 68% of organic products are consumed in 4 countries: Germany, France, Italy and Sweden.

Situation in the Slovak Republic in 2021:
• 859 entities in eco-farming
• total 196 209.9 ha
• which represented 10.19% of the total area of agricultural land
• since 2005 gradual increase from 0.62% (15.000 ha) to 4.93% (93.600 ha) in 2005
• After 2015, the trend of increasing the share of agricultural land in organic agricultural production continued
• the constant increase of this share is aimed at meeting one of the goals of the Environmental Strategy 2030, namely to increase the share of the land managed in this way to at least 13.5% by 2030

Current trends
Today, ecological trends in large-scale fruit production already have the strong support of the governments of individual European countries. The use of chemical sprays to protect against diseases, pests and weeds is not permitted in this fruit growing system, and the range of fertilizers that can be used in this system is also defined by the law.
Under the term organic cultivation, the fruit grower imagines an orchard from which sprays and other chemicals are largely eliminated. Almost all of these pesticides are on an aggressive chemical basis and harm the environment, the animals around us and, last but not least, humans themselves. The task of

organic farming is to eliminate these undesirable effects of chemistry and replace them with more environmentally acceptable measures.
From a legislative point of view, the use of chemical sprays for protection against diseases, pests and weeds is not permitted in this system of fruit growing, and the range of fertilizers that can be used in this system is also defined. However, action against harmful agents needs to be taken and can be done in a number of ways.

Agro-technical measures against harmful factors
Agro-technical measures include e.g. maintaining the correct crop rotation. In no case should stone-fruit planting be followed by stone-fruit replanting at the same site in view of the possible spread of viral diseases. Perfect soil preparation before and during planting, targeted and sensible fertilization, cultivation and mechanical weeding are important. We green the areas between rows and sow grass mixtures on a rye-grass basis with the addition of fescue grass. Clover-grass mixtures are also suitable, which enrich the soil in a natural way with nitrogen. We keep the areas under trees in an no-cover system with mechanical weeding, and with small fruit we mulch with straw, grass or other material.

Biological methods of protection
Biological means of protection include the current trend of introducing new, resistant and tolerant varieties into growing, which do not show symptoms of the most important diseases. In addition to resistant and tolerant varieties, the most common protection is the use of natural enemies of diseases and pests.
Predatory mites (*Typhlodromus pyri*) are already well known which are placed on trees in felt belts, where they reproduce and expand for food. Larvae of *Chrysoperla carnea* are used to kill many species of aphids, but also other insects. The predatory ladybug *Cryptolaemus montrouzieri* is used in biological protection mainly on ornamental trees against worms of the genera *Pseudococcus* and *Planococcus*, but when present on fruit trees it can be used successfully. The most important parasitoid in field conditions is the egg parasite *Trichograma* (especially *Trichogramma evanescens*, *T. cacoeciae, T. dendrolini*), which lays eggs in the eggs of the pest and the larvae of the pest do not hatch from the eggs of the pest, but the adults of the egg parasitoid. It is used against the codling moth (*Cydia pomonella*). In the orchards, the parasitoid *Aphelinus mali* was introduced into Europe against the whooly aphid (*Eriosoma lanigerum*) and the parasitoid *Prospaltella perniciosi* against the San chosé scale.
The most commonly used insect pathogen is *Bacillus thuringiensis*. *B. thuringiensis ssp. Kurstaki* (Lepinox Plus) is effective against butterfly larvae (*Spilotana ocellana*, *Argyroploce variegana*, *Cydia pomonella*, *Euproctis chryssorhoea*, *Lobesia dispar*, *Malacosoma neustrium*, *Hyphantria cunea*, *Operophtera brumata*) and not only on fruit trees.
Of the viruses, apple granulose virus (against *C. pomonella*) is the most commonly used, but their preparation is relatively expensive compared to bacterial and fungal preparations. Viruses multiply only in living organisms and therefore it is necessary to breed a host to reproduce them.
Preparations containing entomopathogenic nematodes are also used against pests. Preparations effective against codling moth (*C. pomonella*, *P. brassicae*) and other pests are known. Nematodes of the genus *Heterorhabditis* are used against Ligurian weevil (*O. ligustici*) and serrated weevil (*Otiorrhynchus sulcatus*) on ornamental plants, strawberries, vines and other crops.

Various plant extracts are used against fungal diseases, which stop or slow down development and spread. These include e.g. extracts of *Azadirachta indica, Chrysanthemum sp., Quassia amara*, horsetail, orange, fennel, sunflower oil, various preparations based on pinolene, fructose, lecithin, vinegar, sucrose, potassium bicarbonate, whey, repellents of plant and animal origin. This also includes basic plant protection products based on sulfur and copper.

Physical and mechanical methods of protection

Among the physical methods of protection in production and already bearing orchards, e.g. protection against late spring frosts in the form of antifreeze irrigation, or fumigation or heating of the air by various methods, which replace chemical sprays to increase frost resistance or to delay flowering.

Mechanical methods of plant protection include measures for the direct destruction of infested parts or entire plants. Protection is done during dormancy, but also through vegetation. This includes e.g. pruning shoots with powdery mildew, fire blight, moniliose, nectrosis, apoplexy and other diseases, infested shoots and parts, it is possible to destroy entire branches or trees (fire blight) if they are calamitously infested by a pest. A very important preventive measure is the destroying of fallen leaves and mummified fruits in the autumn. These residues are a reservoir of spores for the following vegetation.

Modern cultivation technologies and shapes

Another important element in the set of measures to prevent the occurrence of diseases and pests without the use of chemistry are modern cultivation technologies and shapes. The most characteristic element is the reduction of the overall height of the tree. At present, shapes are preferred in which we are able to harvest 80% of the crop from the ground. This is related to the intensification of not only fruit production, but also significantly contributes to the overall health of the tree and orchard. We don't have to care for trees from a ladder or a platform, but we comfortably prune and maintain the whole tree from the ground and we have it basically completely under control.

The spindle shape best meets these criteria. Fruit species for which the technology of spindles is not yet perfectly mastered, we can successfully use e.g. free-growing dwarf-stem, modifications of the hollow crown, not only for peaches, or dwarf-stem with the central leader removed. In addition to the peaches already mentioned, such a system suits essentially all stone fruits.

The main principle we follow is airiness, brightness and maintain of the crown. With overgrown plantings, there is a risk of higher humidity, which is very suitable for the development of adverse, especially fungal diseases. In too dense crowns, pests have a better chance of settling, and access for birds is limited to none. The fruits do not develop optimally due to lack of light, they do not reach the desired color, shape, size and, of course, taste, the differentiation of flower buds for the following vegetation does not take place optimally, not to mention susceptibility to diseases and pests.

Although we manage to grow organic fruit, or fruit that we buy as organic, we observe that it is much less attractive than fruit grown in a conventional way, the fruit is smaller, less colored, uneven in size and shape, and what is the biggest difference, it is affordable much less disadvantageous than conventionally or integrated produced fruit. Unfortunately, at present, the consumer does not look at quality, or origin and method of cultivation, but most in the first place on the price.

INTEGRATED FRUIT PRODUCTION

The strategy of integrated fruit production is based on the recognition of the effectiveness of natural regulatory factors (environmental resistance) and is not aimed at the complete elimination (eradication) of harmful organisms, but at regulating their population at a certain ecologically and economically tolerated level.
Integrated fruit production is, very simply, a kind of intermediate stage between conventional and organic fruit growing.
The term integrated fruit tree protection (referred to as IPM – Integrated Pest Management in the world) means targeted protection that is carried out only when intervention to protect against diseases and pests is needed. In this way, we almost don't use preventive sprays against diseases and pests. Spraying is carried out on the basis of signaling and prognosis and is applied only when it is necessary and the threshold of economic tolerance for individual pests and diseases, or even weeds, is exceeded. This method of protection has significantly reduced the number of sprays through the vegetation, which has significantly reduced the cost of protection and contributes significantly to environmental protection.

Agro-technical interventions are made as preventive measures. These are measures where e.g. by grassing the rows between two rows of trees, it eliminates the growth of weeds; Spraying with a chemical product as frost protection is replaced by frost irrigation or fumigation. Shoots infested with apple powdery mildew are removed by pruning in the early spring, which largely eliminates a possible source of infection for the growing season. Alcohol traps in the number of about 8 pcs / ha is an effective measure in the fight against European shot-hole borer (*Xyleborus dispar*), but also against other pests whose adults are damaged by flowers or fruits. The multiplication of beneficial organisms and their introduction are also effective, especially predatory parasitoids, which are more effective than chemical methods of protection in the long run. Supporting the occurrence of adults and ladybugs is also a very suitable measure.

Pruning and training is also used as a preventive protection factor. This includes a complex of summer pruning, where we reduce the relative humidity of the air, especially by breaking out unnecessary shoots, thus preventing the spread and development of fungal diseases (scab, powdery mildew, monilioses), but also the spread of pests. Related to this measure is the fact that low-stem shapes on week-growing rootstocks, especially slender spindles, are recommended for integrated fruit production, as they are shapes that are airy, bright and thus less accessible to diseases and pests.

A very widespread method for the fight against diseases and pests is the use of natural enemies. By supporting the nesting of birds in the form of birdhouses, we significantly reduce insect pests.
Chemical sprays against pests are done on the basis of signaling according to flight curves. Pheromone traps are placed on the branches of trees and when the presence of the pest reaches a certain critical limit, a spray is applied. A wide variety of pheromones are used to attract males, and the traps also vary in color depending on the pest.
Chemical protection against diseases is carried out in modern orchards using a computer, which signals the need for spraying. The evaluation takes place according to several factors depending on the disease. E.g. spray against apple scab is determined mainly by the length of wetting of the leaves in hours of combination with temperature, which takes into account especially the night and day period of the length of wetting (Mills table). If the conditions for the spread of the disease are met, the computer will give a signal and the worker will spray. Each disease has its own condition and evaluation algorithm. This method is very reliable, but relatively expensive, it does not matter for small gardeners, but in large-scale production they significantly reduce the overall financial costs. On the basis of such and similar attributes, signaling messages are prepared by the national authorities, which are popularly used especially by gardeners.

The integrated pest management in the orchard begins to take place as early as spring. Many harmful species of insects, mites, but also diseases overwinter on fruit trees. Early spring treatment allows wintering pests to be eliminated before their harmful activities begin. During the spring chemical treatment, there is no risk of possible contamination of the fruit with residues of the used preparation. There is also no destruction of useful animals, which are concentrated in orchards, mostly from their surroundings, only after the flowering of fruit trees. With the integrated method of orchard protection, it is necessary to evaluate the species and number of overwintering pests every year. Spring protection should only be done if they are found to be harmful. The low incidence, which is harmless, should be tolerated. Significant financial savings can be achieved with this measure. In addition, there will be enough natural food for natural enemies of pests. With a sufficient number, natural enemies are able to regulate the number of overwintering pests or keep their occurrence in harmless quantities.

The location of the presence of overwintering pests in their economical threshold or above the threshold amount then signals the real need for spring protection of fruit trees. If appropriate regulatory action is not taken during this period, then economically significant damage will occur in the affected orchard.

Even in the next growing period of fruit trees, integrated protection is performed on the basis of signaling, in the event of the initial occurrence of pests, the infectious pressure of the disease according to the course of the weather and other various auxiliary elements.

The most important principles of integrated fruit production are:
• use of such agrotechnical measures that reduce erosion, leakage of harmful substances into groundwater and surface water
• the use of varieties not demanding intensification inputs, which are able to use nutrient reserves mainly from deeper soil layers and from less soluble forms, varieties resistant or tolerant to diseases and pests
• the use of integrated protection against harmful agents (diseases, pests, weeds), which is based on chemical, biological and mechanical principles
• optimization of nutrition and fertilization based on the results of agrochemical analyzes of nutrient content in soil and plants using diagnostic methods to determine the necessary nutrient doses
• favoring the use of organic fertilizers or other sources of organic matter delivered to the soil
• reduction of energy deposits - use of minimal tillage methods, reduction of chemical treatment needs

CURRENT ASPECTS ADDRESSED IN INTENSIVE PLANTINGS

THE IMPORTANCE OF FRUIT SET REGULATION

Modern generations of newly bred varieties of fruit trees have received, among other things, an excessive and often disproportionate set of flowers and, consequently, fruits. If we combine this fact with weakening rootstocks, we get several logical conclusions. If the growth is weakened due to the rootstock, fertility begins very early, often as early as the year of planting. Since the flowering of flowers and fruits is genetically determined, regardless of the age of the tree, we receive from the beginning of the life of the tree an excessive supply of fruits that weaken the tree. Assimilates are preferentially directed to the fruit and thus significantly slows down the growth of the shoots, the tree remains small, does not develop and becomes stressed. To better understand, it is important to know the relationship between growth and fertility.

The relationship between growth and fertility

To explain the relationship between growth and fertility, it is necessary to „visit“ plant physiology. It is necessary to distinguish two concepts that are in an antagonistic relationship (they act against each other). It's growth and fertility. Growth is a process in which the vegetative parts of a fruit tree are created, elongated and differentiated – the tree grows, forms new shoots, leaves, grows in length, forms a green mass. On the other hand, fertility is the process by which flowers and fruits are established and developed.

Phytohormones called auxins are responsible for vegetative growth. Through auxins, there is a prolonged growth of annual shoots. Their strongest synthesis and secretion is in the terminal parts, at the ends of the shoots. Further from the terminal, their influence decreases and the synthesis of cytokinins and gibberellins begin to prevail, which are, among other things, responsible for the formation of generative organs and for the formation of lateral growth, branching respectively.

These two groups of processes are in an antagonistic relationship, there is no or very low synthesis of cytokinins and gibberellins at the site of auxin synthesis and vice-versa. Auxins are therefore responsible for growth, especially in length (including also growth in height). The more perpendicularly the branch grows, the greater the synthesis of auxins is in its terminal, and conversely, the higher the synthesis of auxins in the tissues, the stronger and more perpendicular the growth. We call this phenomenon apical dominance and it is very notable in plums, pears, sweet cherries and some apple varieties. Note, especially on young trees, that the shoots, or growth growing just below or near the terminal, have a direction of growth very similar to the direction of growth of the terminal, i.e. perpendicular to the top. The farther the growth is from the terminal, the greater is the growth-angle of the lateral shoots from the central axis – the influence of auxins decreases and the synthesis of cytokinins and gibberellins begin to prevail.

In practice, this means that on shoots and branches, where the growth is very strong (e.g. vertically growing water-sprouts), we will not find lateral growth, nor flowers and fruits. This is related to the antagonistic action of these two groups of phytohormones. On the contrary, on shoots and branches, which have a more or less horizontal direction of growth, we observe a weak elongation growth, but an even richer set of flowers and fruits.

In the first years of the tree's growth, until the period of full bearing, growth prevails over bearing. It is quite logical; the tree needs to build a skeleton of the crown, solid branches that will bear growth and fruit. Therefore, in the first years after planting, the trees grow more intensively and bear few flowers and fruits. In later years, when the tree ends its juvenile growth phase, it stops growing stronger, the synthesis of auxins decreases and a stronger synthesis of cytokinins and gibberellins begins, ie the formation of flowers and fruits. During this period, we can talk about the balance between growth and fertility. Gradually, as the tree grows older and older, the older and thicker branches begin to dry out, fertility declines and regenerative growth occurs, with which the tree tries to rejuvenate its growth and restore bearing.

It often happens that the trees are overloaded with crops, there are very large amounts of fruits on the branches, which on the one hand drain the assimilates intended for the establishment and differentiation of flower buds for the next season and on the other hand drain the assimilates, which should go to the growth of new shoots, established inflorescence. In this case, cytokinins and gibberellins inhibit the synthesis of auxins. It is also an undesirable phenomenon, because there is alternate bearing, so we have a surplus of crops on the tree for one year and no fruits for the next year. We will deal with the elimination with the use of various types of thinning.
It is therefore very important to maintain a balance between growth and bearing, not to allow growth to prevail over bearing and vice versa. Therefore, in the first years of the tree, we do not make a strong pruning; we need the tree to bear flowers and fruits as soon as possible. We replace the pruning with training in the form of bending and untying of branches and we prefer the so-called green work before dormant pruning (pruning in winter or early spring). We prefer breaking out the shoots, pinching, removing buds on the central axis etc. If we prune stronger during this period, we will only achieve growth support again. The golden rule is that the stronger the tree, the stronger it will grow. On the contrary, if we bend the shoots in the winter, we slow down the vegetative growth and support the formation of flowers and fruits.

Fig. 4. Neglect of thinning on young trees leads to the bending of the central leader, the loss of its dominance and the subsequent growth of side shoots, which delayed bearing. Pruning the side shoots is necessary, which again leads to enhanced growth and delayed bearing. (photo: Mezey)

Alternate bearing

Alternating fertility, alternation, or periodicity of bearing is a problem that we encounter very often not only in gardens, but also in intensive professional production conditions. Current research and study of this problem has revealed its most common causes, and after following a few principles, it is possible to eliminate this problem almost completely.
To clarify the essence of alternation, we visit the physiology again. The main reason is the lack of assimilates for the differentiation of flower buds. It is a process in which the establishment and formation of flower buds for the following vegetation is initiated on the shoots and branches. The start of these physiological processes is in our conditions from about mid to late June, after the end of the most intensive vegetative growth, during the first growth period, and lasts until the arrival of autumn. During the winter, the differentiation stops and is completed in the early spring next year. However, the period during the month of June, until about mid-July, is of the greatest importance. If the tree does not have enough assimilates in combination with sunlight during this period, the differentiation will not take place, the flowers will not be established and the result will be the absence or reduction of the number of flowers and fruits for the next year.

There are many reasons for this. We can divide them into external and internal. External factors include environmental influences. These are sunlight, water, nutrients, low temperatures, frost, drought, soil-care management, and site. Internal factors include e.g. species, variety, rootstock, tree age, physiological condition, and pruning and training systems including summer pruning, disorders in water and nutrient intake, large fruit set.

Light and sunlight are one of the most important "starters" for establishing flower buds. If there is not enough light during the differentiation period, the differentiation will not take place. This condition occurs with trees that are too dense. This may also be due to the growth of regenerative shoots that have grown in response to too strong pruning in winter or early spring. In both cases, a timely summer cut is required, resp. opening the inside of the crown. By "timely" we mean the term until the beginning of the differentiation. Thus, the period of June is suitable for this type of cuts, respectively, breaking out unnecessary shoots. This condition often occurs in larger, taller trees, where light does not penetrate inside the crown, differentiation does not take place, the fruits do not form and they are usually located only around the perimeter of the crown. Such problems occur less frequently with low-stemmed shapes (slender spindle).

Water – nitrogen – drought are factors that have a positive but also a negative effect on differentiation. If there is not enough water in the period June - July, the differentiation starts earlier (drought acts as a stress factor), but it does not go well, it stops. On the contrary, if there is enough water in this period, the differentiation will be successful. Another factor reducing differentiation is the nitrogen content. It affects mainly vegetative growth and since differentiation is a generative process and in an antagonistic relation to growth, differentiation will not proceed optimally. Due to the excess of nitrogen, the growth force will go to the formation of vegetative parts – annual shoots. During this period, therefore, we avoid fertilization, especially with nitrogen.

Species, variety, rootstock. Fruit species, especially from the group of late varieties of pome fruits, enter into differentiation later. On the contrary, the early varieties of pomes and stone fruits enter into differentiation earlier, which is also sooner to end. Rootstock influences the entry into differentiation by the force of growth. If the trees are grafted onto weak-growing rootstocks, they differentiate sooner. On the contrary, larger trees enter into differentiation later. We therefore recommend growing trees on low-growing rootstocks, e.g. in the shape of a slender spindle.

Age, physiological condition and condition of the tree are related to the fact of alternation in that older trees, trees exhausted by excessive crop load in previous year and weakened trees enter differentiation earlier, but since they do not have enough assimilates to succeed, it does not succeed or is imperfect. Locations on shoots near the fruit also do not differentiate at all, as the vast majority of assimilates flow into the fruit. It is therefore logical that trees that have previous year excessive yield are almost completely fruit-free the following year.

Dormant winter pruning or the reaction to a dormant pruning is an effort by the tree to regenerate and replace lost branches by creating relatively thick shoots. Assimilates used for this type of regeneration are at the expense of differentiation, which does not take place. As a result, there are no flowers for next year. So if we plan to rejuvenate the trees harder, let's do it gradually and not all at once.

If we remove most of the negative effects mentioned previously, we on our way to eliminating the alternative. In addition, we know measurements that can be used to support differentiation and thus reduce, even prevent, alternating fertility.
The most effective measure is fruit thinning during or after the natural fruit fall in June. Of course, this is unnecessary if our trees are in poor physiological condition, if the branches are overwhelmed, they are fertilized with nitrogen, if we grow them on too wet soils.

In addition to fruit thinning, it is very appropriate to break out the excess shoots that do not serve to create a crown, during the month of June. Also by hand, by breaking out, we remove the growing water-sprouts and all the branches that cross, grow vertically upwards, interfering with the interstitial or the adjacent tree.
Another support for differentiation is the bending of shoots and branches to a position close to the horizontal. In this way, we weaken the production of auxins, which serve for prolonged growth, and support the synthesis of cytokinins and gibberellins, which, among other things, also serve to produce flowers. Bending should be done in the early spring. On such bent branches, the growth is slowed down and the foundation of flower buds is initiated. From agrotechnical measures, it is appropriate to occasionally loosen the soil under the tree row.

Flower – and fruit thinning by fruit trees
Thinning is a reduction of the excessive flower or fruit set. Fruit trees produce many more flowers than are necessary to ensure a sufficient number of quality fruits. In the case of fertile apple varieties, the effective number of flowers (i.e. the flowers from which we actually pick the fruit) ranges from 1 to 10%. Other flowers fall off; they do not develop fruit respectively.
The fruit quality on the fruit market is becoming more and more important. In accordance to this development, the situation arises the possibility of increasing the price by qualitative indicators. In the case of pome fruit, these indicators are affected by thinning. These are mainly the size of the fruit, the opaque color and the nutrients in the fruit. With the use of fruit thinning, it is possible not to completely reduce, but to a large extent to prevent alternative bearing and thus to achieve relatively stable yields every year.
We know several types of thinning. According to the date, we divide them into flower thinning and fruit thinning. According to the method we speak about manual, chemical and mechanical thinning and their combinations.

Fig. 5. Excessive fruit set, especially in young trees can cause a central leader breakage, which is a huge stress for the tree. (photo: Mezey)

Flower thinning by hand

The flower set is regulated by their manual removal, or with pruning. From the total number of flowers, or flower clusters are removed, depending on the total flower set, about 30% of flowers. We recommend removing the flowers in the phenological stage of the pink bud, the beginning of flowering, or in full bloom. For apple trees, it is advisable to leave only royal flower (terminal flower from the cluster). This method is characterized by high demands on human labor and is therefore unfeasible and unrealized in large-scale production conditions. It is also very time consuming. Flower thinning is more often done by pruning. We remove the whole flowered branches. It is possible to postpone the date of pre-spring, or winter cut until flowering period. In this period, we cut according to the same principles as in the winter, respectively, pre-spring section. We remove thickened, intersecting, vertically growing branches and branches with excessive flower set. With such a cut, we both regulate the flower set and we make winter, or early spring pruning.

Fig. 6. With delayed spring pruning after bloom we will also ensure fruit thinning. Please, use only in adduced reason and situations. (photo: Mezey)

Another option is to remove the flowers, especially for apricots, from the stage of the white bud to the full bloom by manually rummaging through the flowering branch.

Manual fruit thinning

We recommend this method of thinning especially for small gardens and small growers. It is inefficient for large-scale production conditions because it is laborious, which is the most expensive.

Fruit thinning is done in time during the June fruit fall. We remove the weakest developed, damaged, degenerated fruits. It is mechanically recommended to tear the fruits at a distance of 0.15 – 0.20 m from each other. It is recommended to reduce the thin so that there are 30 – 40 developed leaves per fruit. Another guide to proper acceptance is to leave 1 – 2 fruits in one fruit cluster. It is appropriate to

keep the so-called royal fruit. It arises from a royal flower, which usually blooms in a cluster first and has the best chance of developing this flower into the highest quality fruit.

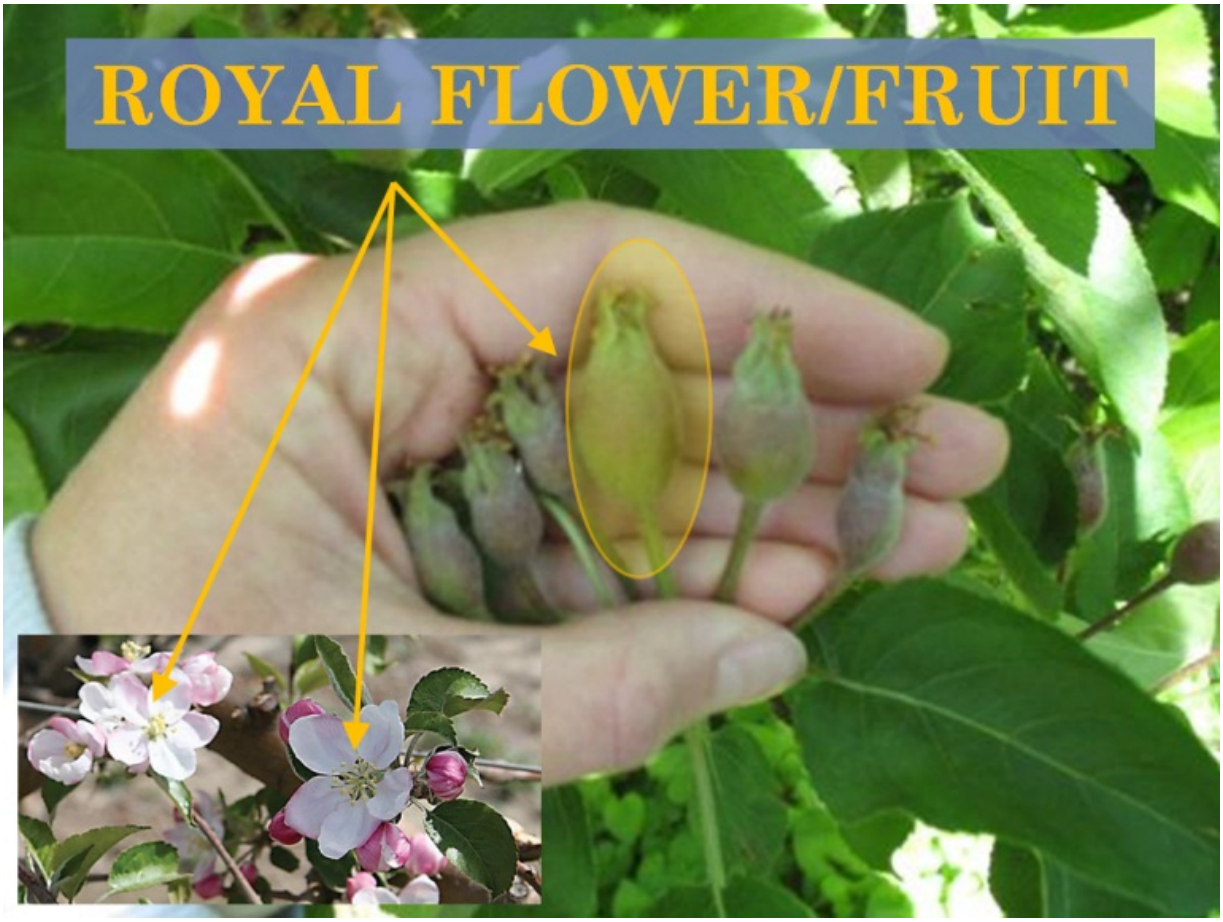


Fig. 7. When thinning flowers, but also fruits, we try to keep the flower that bloomed first, the so-called royal flower and is expected to develop the largest fruit. (photo: Mezey)

Another principle that can be followed is yield programming. We leave as many fruits on the tree as we have calculated in advance. This is in line with the principles and weight limits at which trees do not exhaust due to over-harvesting.

Fig. 8. We can also do fruit thinning with special scissors. We leave 1-2 fruits (apples, pears) in one flower cluster, or 100-150 mm between two fruits. (photo: Mezey)

Chemical thinning of flowers

Chemical thinning has its justification mainly in large-scale production, because it is possible to treat a large number of trees in a short time. However, it can also be used in smaller gardens.

We recommend that thinning can be carried out even if there is no alternation so that the tree is not exhausted by excessive fruit set. Excessive yield lead to exhausting and consequent lower yield in the coming year.

Substances based on salts, acids and phytohormones are used to thin the flowers and consist in burning the flower organs, which prevents subsequent pollination.

It is also possible to regulate fruit production by using fertilizers, e.g. use of leaf urea spray at a concentration of 60 – 80 kg / ha in the pink bud phenophase and use of ammonium sulphate (ATS) 58% solution in full bloom phenophase and also ammonia. In addition to the flower-reducing effect, the use of these sprays also has a fertilizing effect, so it is necessary to include them in the fertilizer amount in order to prevent the over-fertilization of the trees.

There are several substances used for chemical thinning, it is possible to apply only approved ones – for this purpose. Different products with different nature of action and effect are used in the world, depending on the date of application, which can be applied at the time of full bloom, shortly after flowering, but also several weeks after flowering. The date of application depends on the specific flower set and the condition of the tree in a given year, but the following scheme is most often used:

- application in full bloom
- application after petal fall
- application at fruit size 10 – 22mm

In the case of apricots, the classic chemical thinning substances have been not proved, flowers are being burned excessively, so alternatives in the form of wetting agents are being tested.

Combination of chemical flowers thinning with manual thinning of fruits

The chemical thinning itself is not as good as the manual thinning. Although it reduces the excessive number of flowers, respectively small fruits, but the effect will never be as perfect as with manual thinning. However, in large-scale production conditions, if manual thinning is the only measurement to manage excessive fruit set, is very costly and time-consuming. The most suitable combination proved to be the use of chemical thinning at the time of flowering in combination with manual fruit thinning at the time of June fruit fall. After the chemical thinning, there are relatively few fruits left on the tree that have to be thinned by hand, which is not time consuming. It is again a technology developed mainly for large-scale production systems, which minimizes the need for manual labor and thus reduces costs. This is a relatively inefficient way for small gardeners, because for the small number of trees is hand fruit thinning the most convenient.

Mechanical fruit thinning

Mechanical method of fruit thinning is the use of various components that rotate by means of a coupled mechanism with the tractor's crankshaft and mechanically embrace blooming flowers (e.g. the Darwin machine). Different ropes and nylons of different thicknesses and rotations are used. It is a way that is a kind of ecological alternative to chemical thinning. Its disadvantage lies in the mechanical damage to flowers and plant organs and is not recommended, especially in areas where the incidence of fireblight (*Erwinia amylovora*) is present. After such type of thinning we recommend to spray a copper substance to avoid infection by bacteria or fungi.

Use of thinning in various fruit species

We recommend flower – and fruit-thinning, especially for apples, pears and peaches. For other stone fruits, the use is essential for young apricot and plum trees, especially at the central axis. E.g. in the case of plums and apricots, it is possible to reduce the flowers together with pruning by removing the entire flowering branches. Various forms of chemical thinning have also been tried with varying success. There is no justification for thinning of cherries.

The thinning is especially effective for taller trees, where there is a significant risk of exhaustion due to excess yield, but also in intensive plantings of slender spindles has its irreplaceable place in growing quality fruits and ensuring sufficient assimilates for the following vegetation.
It is absolutely necessary to thin over all young trees until the period of full bearing in apple, pear, peach, apricot and plum trees. The following table shows the approximate number of fruits per tree depending on the age of the apple trees. With this quantity, the optimal quality and size of the fruit will be achieved, the tree will not be exhausted and there will be plenty of new shoots on which the flower buds will be differentiated for the following year.

Tab. 3. Optimal fruit set per tree in accordance to age and apple variety on M9 rootstock.

Tree age	Braeburn, Golden Delicious, Pinova	Gala, Pink Lady, Granny Smith	Fuji
2 years	30 – 40 pcs	25 – 30 pcs	25 – 30 pcs
3 years	50 – 60 pcs	45 – 50 pcs	45 – 50 pcs
4 years	70 – 80 pcs	60 – 70 pcs	60 – 65 pcs
5 years	100 – 110 pcs	90 –100 pcs	70 – 75 pcs

Even by apricots, it is important to regulate the yield depending on the age of the tree, respectively from the trunk diameter. If the regulation on the spindles of the apricots is not corrected, the tree will be exhausted and may eventually receive apoplexy. There are several rules for crop regulation that need to be followed. The optimal quality of apricot fruits is achieved at a ratio of 4 – 6 fruits per cm^2 of trunk diameter. If e.g. trunk diameter is 10 cm, so the number of fruits per tree is calculated according to the following formula: number of fruits per tree = $\pi \times r^2$ = 3.14 x 52 = 78.5 cm^2 x 4 to 6 fruits per / cm^2 = 314 to 471 fruits. On average, this means that with a trunk diameter of 10 cm, the number of fruits 3 – 4 weeks after full bloom should be approximately at the level of 400 fruits per tree. The following table shows the approximate quantities of fruit per tree:

Tab. 4. Approximate quantities of apricot fruits per tree depending on the trunk diameter.

Trunk diameter (cm)	Number of fruits per tree (pcs)	Yield per tree by 50g fruit weight (kg)
5	98	5
6	141	7
7	192	10
8	251	13
9	318	16
10	393	20

By hand-thinning of pears and peaches, the same applies as by apples. By plum the fruit numbers are slightly higher than for apricots. In general, however, it can be said that one meter of shoot should not have more fruits than 10, respectively; the distance between the two fruits should not be less than 10 – 15cm.

Necessity for thinning for individual species:

Apples	thinning is essential
Pears	thinning is essential
Peaches	thinning is essential
Plums	in young trees essential, especially in central axis, in following years according to fruit set and tree condition
Apricots	in young trees essential, especially in central axis, in following years according to fruit set and tree condition
Sweet-cherry	in some varieties and some cases only chemical
Sour-cherry	thinning is not necessary
Berry fruit	thinning is not necessary

THE PRESENT PHENOMENON: NATURAL ELEMENTS

In recent years, we are witnessing significant changes in the climate area, which is reflected in the daily lives of all of us. Increasingly, the weather is unpredictable, it is warm in winter, cold in summer, spring or autumn, as we know it, practically no longer exists. These phenomena have a negative effect on us and it is similar in orchards, vineyards and practically in the whole plant production.

Weather anomalies occur throughout the year, it is not just the specifics of the winter or summer months. The most common ones include late spring frosts, absence of winter frosts, hail, gust wind, storm rainfall, uneven rainfall distribution, sunburn, heat damage in orchards, temperature fluctuations, the spread of new pests and diseases, increasing generations of pests and changes to their bionomy and behavior.

Orchard designers must take all these factors into account and adapt the project accordingly, if the situation and financial capabilities of the investor allow. We start with the regionalization of selected species, and here it is necessary to say perhaps the only positive that in the recent period, it is possible to grow fruit at higher altitudes, respectively, further north than before. Otherwise, we are only forced to fight against these negatives of nature.

Late spring frosts

The phenomenon of late spring frosts has been here for a long time, but in recent years their frequency has been increasing and what is worse, it is not just classic radiation frosts, but e.g. in 2020 it was a winter, or advection frost, which has not been here before. To explain, it is necessary to say that the radiation from the sun is shortwave radiation (up to 3µm) and longwave radiation (from 3 to 100µm) is radiation e.g. from the earth's surface, or from clouds with sufficient moisture. If the radiation balance is negative, radiation cooling will occur. The layer in which it cools (e.g. the ground surface) cools the layer above it (orchard) and the temperature drops. This type occurs at night because the earth's surface does not heat up. If it is clear and windless, a radiation mist is formed (dew point reached). The heat transferred to the air by the soil is lost with the rising warmer and therefore lighter air. Cold and heavy air accumulates at the soil surface, resulting in the most damaged parts of the plants located low above the soil. The air temperature drops the most just before sunrise, and the temperature drop is more pronounced when the air is dry. As the fog thickens, the flow of heat from the earth's surface ceases, and when the fog or clouds form, the temperature drop stops.

Fig. 9. Late spring frost damage on sweet-cherry and apricot flowers. (photo: Mezey)

In our latitudes, we know this phenomenon as the May chills. These are more or less regular cooling with subsequent ground frosts after the invasion of cold air of Arctic origin. In May, the land is already warming up rapidly, but the ocean is lagging behind in heating, creating an inequality of air pressure

between the land and the ocean. The increasing temperature difference is also reflected in the distribution of air pressure. This imbalance is sometimes offset by the ingress of cold sea air into the mainland, which results in significant cooling. However, there is often a "bifurcation" of the maximum number of frost days to the first, around 8 – 9, and the second 20 – 21 May.

Advection frosts are caused by the flow of cold air masses from higher latitudes (most often from the north and northeast) into our area. In this case, the effect of low temperature is amplified by the drying wind, which is not present in the case of radiation frosts. This type of frost is the most harmful because conventional interventions against them generally do not work, so protection against them is limited.

To clarify, it is necessary to specify how fruit trees behave during the winter months. After the leaves fall, phytohormones protecting the tissues from frost flow into the tissues, which act until about the middle of January. From this period, the plants in the dormant conditions due by the cold. If the cold is insufficient, a warmer period occurs, the sap begins to flow slowly, the tissues and buds continue to develop, and when the temperature drops below a critical value depending on the degree of tissue differentiation, they freeze, resp. will be damaged. And here comes the problem with warm winters, because the vegetation is already waking up, the vegetation starts, and when advection frosts (that is, classic winter frosts) occur, it is usually fatal.

How is it possible to fight these phenomena? Already during the creation of the planting project, we try to place the planting instead of flat land on rather gentle slopes or hills, from where the cold air can at least partially flow. When inspecting the terrain itself, if it is overgrown with trees that would prevent the air from flowing downwards, and if the situation and laws allow, it is advisable to at least dilute such a stand or remove it completely so that the cold air can drain to lower positions. We avoid placing orchards in valleys, freezing pits, or basins. When choosing the location, it is necessary to take into account the type of soil, but also the growing shape, respectively, final height of the trees. The relationship between soil type, cultivation shape and terrain relief proved to be a relatively bad combination. Damages after late spring frosts tend to be highest on sandy soils that warm up easily and quickly (earlier start into vegetation) in combination with a slender spindle (low trees) on the plain. In the same localities, no damage was recorded in the case of higher tree shapes (dwarf-stem, quarter-stem).

Fig. 10. Typical frost damage on young apple fruits. (photo: Mezey)

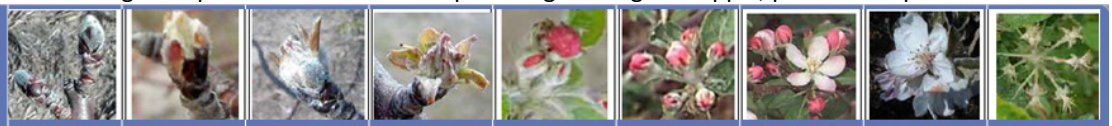
Fig. 11. Paraffin candles work on the principle of flame burning, which heats the air from which the plant tissues are heated. They are effective up to approx. -4°C and warm air must be mixed and pressed down using helicopters. (photo: Mezey)

Active antifreeze measures include heating the air by burning various materials (straw, paraffin candles, gas) and the subsequent dispersal of warm air by low-flying helicopters at low speeds, stationary or mobile turbines, we also use mist generators that simulate clouds and thus warm air, so warm has no chance to escape into the upper atmosphere. Such an antifreeze system was able to raise the air temperature by 3°C. In the case of strawberries, the covering of the entire stand with textiles helps in part. In some cases, we also use antifreeze sprays (vitamin E, cryoprotectants, boron, copper, hormones, morphoregulators and others)

Fig. 12. Stationary propellers are used to mix the air within the orchard. The fog generator creates a layer above the crowns, through which warm air does not penetrate into the higher layers of the atmosphere. It is also used in combination with paraffin candles. (photo: Mezey)

The most effective measure is anti-frost irrigation, which can protect orchards up to air temperatures of -6 to -7°C. In addition to the costs themselves, which are at the level of 17 – 20,000 EUR / ha, it is necessary to realize that this system needs a huge amount of water at one time, which most wells cannot supply. The need for water for antifreeze irrigation is 2 – 4 mm / hour / m2, which in hourly operation represents a volume of 20-40 m^3 of water per ha per hour. We run the irrigation just before the frost occurs and the water supply must be continuous throughout the frost period, which is sometimes 4 – 6 hours. Subsequently, according to this, we calculate the water demand and choose the size of the collection tank. E.g. for 6 hours of system operation, the water requirement is 120 – 240 m^3. For this reason, the construction of a retention water reservoir (pond) or special reservoirs (Genap) is often included in the project. If we do not consider to have anti-frost irrigation, the tank is not needed, but we still strongly recommend it, also due to the possibility of using this system as an air conditioning irrigator again sunburn, but last but not least for the availability of water as such.
As a precaution after a freezing night, it is recommended to apply gibberellins by spraying all cultures. If we know that a freezing night is coming, we recommend spraying 1 – 2 days before the freezing night with urea or available bacteria-based products (bacteria act as a condensation core). An important measure before the frost night is the release of drip irrigation, which will ensure higher humidity and thus reduce the physical nature of frost. Equally important is mowing the soil under the trees.

Tab. 5. Critical damage temperatures in relation to phenological stages in apple, peach and apricot trees.



	BBCH 01-03	BBCH 07-09	BBCH 10	BBCH 56	BBCH 57	BBCH 59	BBCH 61	BBCH 65	BBCH 69
OST*	-8.9°C	-8.9°C	-5.6°C	-2.8°C	-2.8°C	-2.2°C	-2.2°C	-1.7°C	-1.7°C
10% damage	-9.4°C	-7.8	-5°C	-2.8°C	-2.2°C	-2.2°C	-2.2°C	-2.2°C	-2.2°C
90% damage	-16.7°C	-12.2°C	-9.4°C	-6.1°C	-4.4°C	-3.9°C	-3.9°C	-3.9°C	-3.9°C

peach	BBCH 01-03	BBCH 07-09	BBCH 10	BBCH 57	BBCH 61	BBCH 65	BBCH 69
OST*	-5°C	-	-	-3.9°C	-	-2.8°C	-1.1°C
10% dam.	-7.8°C	-6.1°C	-5°C	-3.9°C	-3.3°C	-2.8°C	-2.8°C
90% dam.	-17.2°C	-15°C	-12.8°C	-9.4°C	-6.1°C	-4.4°C	-3.9°C

apricots	BBCH 01-03	BBCH 07-09	BBCH 57	BBCH 61	BBCH 65	BBCH 69	BBCH 71
OST*	-	-5°C	-	-	-2.2°C	-	-0.6°C
10% dam.	-9.4°C	-6.7°C	-5.6°C	-3.9°C	-2.8°C	-2.8°C	-2.2°C
90% dam.	-	-17.8°C	-12.8°C	-7.2°C	-5.6°C	-4.4°C	-3.9°C

OST – the lowest temperature during 30 minutes with no damage

Precipitation activity

Climate change in our territory also brings with it significant changes in precipitation conditions. This has been confirmed by the last years. If we look at the characteristics of years in terms of temperatures and precipitation, they are usually normal, but if we look at the characteristics of individual months, we come across extremes. A nice example is the year 2016, when the dry and wet months alternated almost regularly. Of course, these fluctuations are not good, because fruit plants, and especially shrubs, need a regular supply of water, and we need to compensate for these extremes with additional irrigation. There are many similar examples.

Tab. 6. Precipitation characteristics of the year 2016 (Dvory nad Žitavou).

2016	**Rainfall**	**normal 1950-1981**	**n**	**Characteristics**
	(mm)	**(mm)**	**(%)**	
I.	42,6	31	137,42	moist
II.	114	32	356,25	extremely moist
III.	6,4	33	19,39	extremely dry
IV.	22,8	43	53,02	dry

V.	101,2	55	184,00	very moist
VI.	23	70	32,86	very dry
VII.	117,6	64	183,75	very moist
VIII.	20,8	58	35,86	very dry
IX.	40,2	37	108,65	normal
X.	46,3	41	112,93	normal
XI.	35,2	54	65,19	dry
XII.	6	43	13,95	extremely dry
sum	**576,1**	**561**	**102,69**	**normal**

Designing and building a currently high-intensity spindle orchard without irrigation is very risky and we don´t recommend it. Although it comes at a cost, the sophisticated irrigation system ensures high and regular crops, and contributes to the growth of new shoots, on which flowers and fruits will emerge in the future. Unfortunately, torrential rains are becoming more and more common, causing damage especially in more exposed places, where they are able to float the soil to the lower parts of the orchard. For this reason, we are putting green lines into orchards. In the past, they were grass mixtures with a predominance of rye-grass, but now they have also added meadow mixtures, which in addition to all the functions of grass mixtures are habitats for various useful organisms, including bees, so honey plants are also included in the mixtures.

Hail

Hail does not need to be introduced, it is also a phenomenon that occurs relatively often, and given the current frequency of this meteorological phenomenon, it is almost necessary to install a support structure with anti-hail nets. On the other hand, a modern super-intensive spindle-shaped orchard also needs a supporting structure, as it would without that not bear the high amount of the fruit (yields 80-100 t / ha). At the same time, it also serves as protection against sunburn, which has affected the fruit relatively often in recent years, and also as protection of the trees against strong wind, which are an accompanying phenomenon of heavy storms associated with torrential rains.

Tab. 7. Hail characteristics by intensity categories.

intensity category	**Diameter (mm)**	**Kinetic energy (J/m2)**	**Damage intensity**
H0	5	0-20	without damage
H1	5-15	20+	Moderate plant damage
H2	10-20	100+	Severe damage on fruits and leaves
H3	20-30	300+	Heavy damage on fruits and leaves and wood
H4	25-40	500+	
H5	30-50	800+	*Possibility of injury*
H6	40-60		
H7	50-75		*Severe injury*
H8	60-90		
H9	75-100		*Heavy and also fatal injury*
H10	more than 100		*Heavy and also fatal injury*

As a further measure against hail, cannons are used that fire a mixture of air and acetylene into the atmosphere at regular intervals, creating a pressure wave that transports warmer air from the lower atmosphere to the upper atmosphere, reducing hail after impact on the earth's surface, or completely melt.

Fig. 13. Vertical anti-hail net (Whailex) and classic horizontal nets (Voen, Germany). (photo: Mezey)

Sunburn

Sunburn has been a major problem in recent years because the damage is irreversible and will ultimately cause the fruit to rot. There are several types of damage and not all of them cause visible damage to the fruit, sometimes there is only a slight loss of color on the skin, but most fruits are more severely damaged and the fruits are unsaleable. Sunburn can occur at virtually any time during the growing season, but most often in June-September. If the damage is during the months of June-July, these fruits usually fall off and contribute to the natural regulation of excessive fruit set. Later damage is worse because the fruits mostly remain on the trees. Damage occurs when the temperature around the fruit rises above about 40 °C and the sun's ray's fall directly on the surface of the fruit. A certain type of sunburn also includes sunburn due to the "magnifier effect", if drops (water, spray) are present on the fruit. We observe a more frequent occurrence of sunburn on trees that are not or are irregularly irrigated. The main cause of damage is the effect of heating in combination with UV radiation, but also sudden changes in light conditions in the crown, even at lower temperatures (e.g. after a summer pruning).

Sunburn necrosis – dark brown to black spots are formed, they are formed in direct sunlight by the heat falling on the fruit. Fruit surface temperature +/- 52 °C for 10 minutes is required.

Sunburn browning – yellow, light brown almost unnoticeable places, less intense sunlight and lower surface temperature are enough, the cells do not die away, the damage is usually only superficial. Damage to the flesh may be noticeable when removed from the cold store. It occurs when the surface temperature of the fruit reaches 46 – 49 °C in 1 hour.

Photo oxidative sunburn – white, faded spots on the skin, which later turn brown and may necrotize. They can occur at lower air and fruit temperatures (even less than 45 °C). The damage is more evident after a sudden increase in sunlight (summer pruning) than when the branch is bent under the weight of the crop.

Sunburn is problematic to prevent completely, but some measures are relatively effective. The use of anti-hail nets, which sufficiently dampen and disperse the sun's rays, seems to be the most effective. Furthermore, it is not advisable to make a summer pruning if the trees are in direct sunlight, it is better to wait for a cloudy day so that the trees do not receive too much light shock. Too strong reduction of leaves, or a strong summer pruning also helps burn the fruits. Even and regular (drip) irrigation of trees is also important, especially during the hottest days. If an antifreeze irrigation system is installed in the set, it can be used as an air conditioner, thus reducing the surface temperature of the fruit. Air temperature is a good indicator, but meteorological instruments always measure it in the shade, so the surface temperature of the fruit is always 10 – 18 °C higher.

Tab. 8. Approximate values of air temperature measured in the shade in connection with the formation of sunburn.

Air temperature	Sunburn type
Higher than 40°C	necrotic sunburn (fruit surface temperature 52°C for 10 min)
Higher than 35°C	sunburn browning (fruit surface temperature 46-49°C for, 1 hour)
Between 30-35°C	depends on, wind, intensity of sunlight (clouds) and the degree of acclimatization of the fruits to sunlight

Very similar symptoms, although in our conditions only sporadically so far, occur on the fruits even when damaged by heat in the orchard. It occurs at air temperatures above 40 °C in the second half of the vegetation. Symptoms in the form of banded or circular overlaps when the flesh is spongy and brown. The second form does not damage the skin, but the flesh is brown, disintegrated and hot. It occurs at a time when there is more sugar in the pulp and at the time of harvest the temperature is above 32 °C.

Fig. 14. Foto-oxidative sunburn in combination of necrotic sunburn and brown rot. (photo: Mezey)

Fig. 15. Foto-oxidative sunburn. (photo: Mezey)

Fig. 16. Suburn browning. (photo: Mezey)

EFFECT OF CLIMATE CHANGE ON MILD CLIMATE ZONE FRUITS

The current, relatively often discussed and presented topic in the media regarding global warming and climate change is also very closely related to fruit trees. There are many studies, scientific papers and professional conferences dealing with this issue.

Greenhouse effect and temperature changes

At present, the effects of the growing greenhouse effect of the atmosphere on the growth of air temperature averages around the Earth (global warming) are the best examined. Depending on how humankind behaves in the next 100 years in terms of greenhouse gas emissions, the average annual temperature will gradually increase by 2.0 to 4.0 °C compared to the 1971 – 2000 averages. This means that the temperature conditions in the Danube Plain will gradually move in our country, probably somewhere in the area from Banská Bystrica to Orava. However, even at air temperatures, it is not possible to rule out an exceptional climate change scenario, which envisages a change in the Gulf Stream by cooling it by a few °C relatively suddenly in north-western Europe. According to all climate change scenarios, a more significant increase in temperature is expected in the winter months; in summer, the increase in temperature should be less pronounced.

In the context of fruit growing, climate change can have a huge direct and indirect impact, which is already evident in recent years. Due to the change in temperature and precipitation conditions, there are increasing periods of drought in our region, which causes stress for fruit trees. This stress causes a general weakening of trees, which are more or less susceptible to diseases, but also pests. Drought contributes directly to e.g. to the widespread of mites in particular. The additional irrigation systems used to alleviate the drought are often not sufficient, especially for intense and week-growing shapes. For optimal growth, it is necessary to have irrigated the entire area of the orchard, not only the areas of the root system, respectively, soil under the trees. The solution could be partly higher growing shapes on stronger growing rootstocks, which would lead to a reduction in specific bearing per unit area, which can sometimes be economically unprofitable, especially in the production of fruit for direct consumption.

Precipitation changes

In addition to an increase in monthly air temperature averages of 2 – 4 °C, the scenarios assume an increase in air humidity averages of 13 – 23% by 2075. With higher humidity, the daily precipitation can increase by another 20%, or even more in the case of storm showers. None of the climate scenarios precludes that in the future there will continue to be low air pressure furrows in Central Europe or individual cyclones, which are necessary for the occurrence of several days of intense torrential rains with flood consequences. Almost all scenarios in our country assume a decrease in monthly total precipitation in the summer of up to 16%. Thus, an increase in air temperature can be expected to increase the risk of drought, but also to increase the risk of storm-rainfall precipitation totals (short-term precipitation totals lasting from a few minutes to several days). Atmospheric currents can also experience temporary fluctuations, which can result in longer wet or dry periods in the same places.

Storm-rains are a common phenomenon, when a large amount of precipitation falls in a short period of time, but the soil cannot accept them, drains into lower parts and remains practically unused, at the same time, it causes water erosion on sloping land. For this reason, the construction of water retention tanks is highly recommended, which are able to accumulate more water and can be used for additional irrigation if necessary.

Changes in overwintering

Other significant anticipated changes will relate to overwintering conditions, which mainly affect extreme minimum temperatures, the height and duration of the snow cover and the depth of soil freezing. In general, deteriorating wintering conditions due to the absence of a snow cover can be expected in the future. The expected changes in the physical and chemical properties of the soil,

especially warming and drying, are also of considerable importance. Higher temperatures will accelerate the decomposition of organic matter and also likely stimulate the growth of roots. In the arid areas of the Slovak Republic, especially on the sandy soils of Záhorie, wind erosion will be significantly increased and, conversely, in higher altitudes and mountain areas of Slovakia favorable conditions for water erosion will be created in the summer months due to increased storm activity.

Changes in the incidence of pests and diseases

At higher temperatures in the future, changes in the incidence of diseases, pests and weeds are also expected, namely, for example, a higher incidence of brown rot caused by the fungus *Monilia fructigena*, powdery mildew, apple powdery mildew and a higher incidence of viral diseases. Extremely cold winters are also important for the occurrence of pests. Low winter temperatures reduce e.g. occurrence of cherry fruit fly but also other pests. High air and soil moisture can, in turn, promote the occurrence of aphids, which can cause an even greater expansion of the plum pox virus. The impact of rising temperatures will also have a significant impact on the number of generations of codling moth, when we expect up to three generations of the most important apple pest to occur in the southern districts. In correlation with precipitation conditions, dry summers affect the diapause, especially by the codling moth, but it is difficult to determine what percentage of the population goes into the diapause. Up to 50% of the population can go through it, but 5% will not go at all. For this reason, this change will also affect the flight activity in the following year. In the first generation - hatching of hibernating butterflies from pupae - the data can be quite accurate, so it is possible to estimate not only the beginning but also the subsequent hatching, but not its intensity, the number of hatching butterflies, because it is not according to the sequence of entering the diapause, but according to completely different, apparently genetically and physiologically dependent and as yet undetected factors, so it does not follow the activity of the previous year. We are witnessing, especially in southern Slovakia, that the flight activity is a mixture of both generations. It is this fact that makes it difficult to determine the maximum flight activity and thus targeted protection, because butterflies fly practically throughout the whole vegetation period.

The change also concerns the traditional dates of harmfulness of individual species, when the differences compared to the past are depending on the phenological stages and vegetation for several weeks. Therefore, it is more accurate to monitor the activity of pests according to the sums of effective temperatures.

In addition, new species of pests are beginning to appear in our territory, against which the natural defense systems of orchard ecosystems have not yet been developed. This includes e.g. *Drosophyla suzuki*, *Rhagoletis cingulata* and *Rhagoletis completa*, fruit-damaging worms, especially *Halyomorpha halys*, but also *Euschistus conspersus* and *Chinavia hilaris*, but also *Harmonia axiridis*, which feeds also on pests but then focuses on biological predators as well.

Phenological stages changes

All the mentioned climatic characteristics will significantly affect and according to our observations already affect the changes in the beginning, length and course of phenological stages.

When comparing the average onset of the phenological stages "beginning of flowering" in apple trees, a shift of 12 – 16 days is evident. This means that apple trees bloom on average 15 days earlier than during the years 1961 – 1990. A similar trend is evident in the phenological stages of "beginning of ripening", when we found that apple varieties currently ripen on average 24 – 29 days earlier than apple varieties in 1961 – 1990.

Assuming a reduction in total precipitation, or an increase in temperature without a change in precipitation, additional irrigation will be necessary in intensive orchards to a greater extent than is currently the case. The lower total precipitation in the winter months will not ensure sufficient winter moisture, which will also result in an increased need for additional irrigation, mainly during blooming period.

It is also assumed that overall global warming and climate change will not only affect the onset and duration of phenological stages, but also their course. If the risk of late spring frosts is reduced, frosty

days and nights will not overlap with the flowering dates of fruit trees. With an earlier onset of temperatures, there will also be an earlier onset of infectious pressure, especially scab and powdery mildew, which will result in an earlier period of spraying against these diseases. With the reduction, resp. by stagnation of the total precipitation in combination with increasing temperature during the vegetation, the conditions for the occurrence of scab will be less favorable (scab require warm but humid weather to spread). As the average annual temperature as well as the average monthly temperatures will increase during the winter months, it is possible that the infectious pressure of some pests and diseases will be higher (low frosts will not cause sufficient pest control).
As a result of these conclusions, there are assumptions that the cultivation of varieties that have so far been zoned in the warmest areas will be possible to grow in higher altitudes, which will contribute to the expansion of planting areas.

ESTABILISHMENT COSTS FOR INTENSIVE FRUIT ORCHARD

Leaving aside the fact that we already have own the land, or we rent it and the species and variety requirements are met in relation to the location and climatic characteristics of the area, it is necessary to think about a number of other requirements that have to planting set to be.

Soil preparation

One of the most important operation is, in addition to knowledge of soil characteristics and type of soil, the agrochemical soil testing (AST), or soil analyses. Without this characteristic, there is no need to take further steps. Within AST, it is necessary to know the content of N, P, K, Ca, Mg, Fe, Cox (content of organic matter, humus) and we must know the value of the soil reaction (pH) and the content of $CaCO_3$. Based on these facts, we approach the fertilization of the soil with organic substrate, ideally 80-100t of livestock manure per ha. After deducting the nutrients contained in manure, we calculate and supply the rest of the nutrients to the soil in the form of industrial fertilizers. For large amounts, this dose can be applied twice (e.g. autumn and spring). It is also important to know the pH level of soil. It happens quite often that the grower wants to plant strawberries or blueberries, but the soil reaction is too alkaline and the pH for strawberries and blueberries must be in the acidic range. Raising the pH is not usually a problem, it occurs when we need to lower the pH. This fact must also be borne in mind, perhaps before we decide to rent or buy land, because in addition to the financial costs, such land improvement is also time-consuming.

Another fact, especially the time in relation to the land is the question of what was on the area before. If it is an area that is overgrown with unnecessary trees, shrubs, or there is a meadow there, it is necessary to remove this and again, depending on the nutrient content, we decide whether to grow preceding crops, which ones and for how long. The same applies if there was or still is an orchard on the plot. Usually, soil preparation in this case takes two, or three years. If it is a so-called virgin land, one year is usually enough.

The investment costs at this stage consist of material and labor costs. For land where there is only ruderal vegetation up to the height of 0.15 – 0.20 m and AST has shown standard values, the price is approximately at the level of 4000 – 5000,-EUR/ha, which is usually about 5% of the total investment costs.

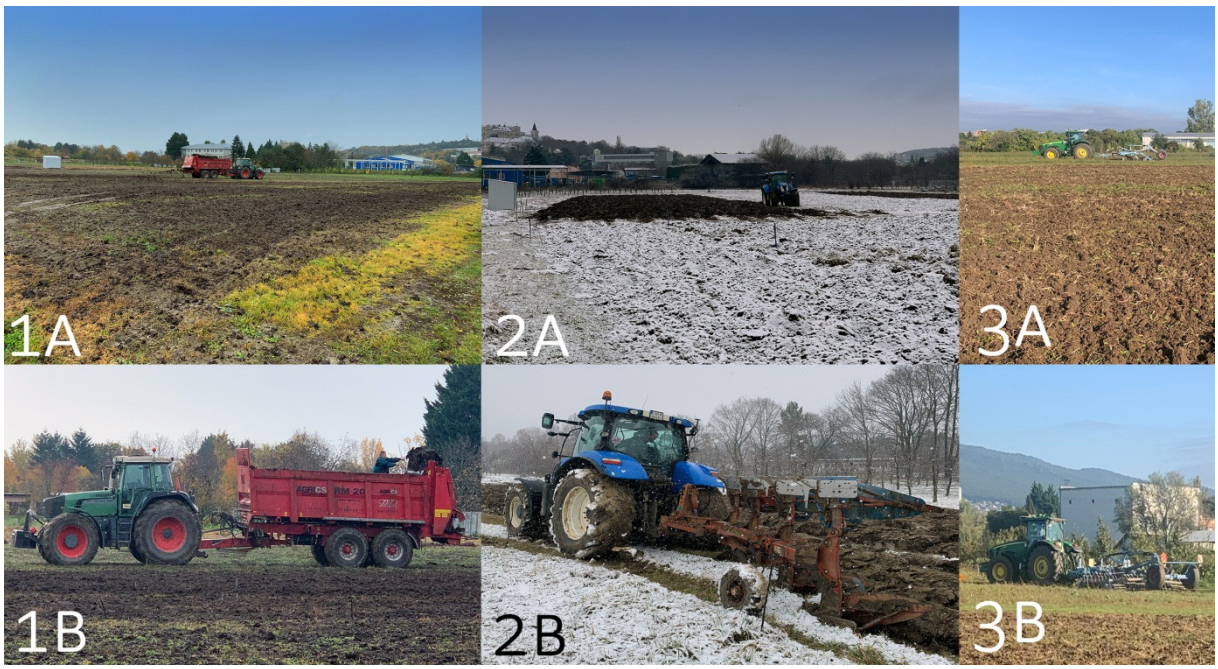


Fig. 17. Soil preparation. 1A, 1B – application of livestock manure in autumn, 2A, 2B – Subsoil ploughing without levelling in November. 3A, 3B – Cultipackering in early spring.

Fence construction

The fencing of the orchard has its justification, especially in localities where there is a risk of damage caused by wild- animals (rabbits, roe, dear, boar, etc.) as in the case of crop protection from thefts. Depending on the risk of attack, we usually choose classic, branch or farm galvanized and plastic-coated mesh. In most cases, it is a farm mesh 180 cm high. Pillars are mostly galvanized with a protective coating with a diameter of 48 mm and a height of 250 cm and, depending on the terrain, equipped with side struts. Pillars can also be from acacia or concrete, but they are more expensive and their financial cost for transportation is also more expensive. In most cases, underburden boards are also recommended, especially in areas where there is a risk of wild boars as well as rabbits. On the other hand, when a wild boar thinks he wants to enter an orchard, he enters. However, it is a reliable protection against rabbits, even though the price is about 30% of the total price of fencing, including labor.

Barbed wire is stretched in locations where there is a risk of theft, some investors also ask for razor wire. The approximate price for the above-mentioned common fencing meter is around 12, - EUR per common meter, even with work. Depending on the size of the area, it is necessary to install gates and also ensure that the animals in particular do not get under them. It should also be noted that the length of the fence can increase significantly depending on the shape of the land. For example, on a square plot of land with an area of 1 ha with sides 100m long, we need 400m of fencing, but on the same rectangular plot of land with dimensions of 200x50m, we already need 500m of fencing, which is 20% more. The total costs for the construction of fencing are approximately at the level of 7 – 10,000 EUR / ha, depending on the design, and represent about 9% of the total costs.

Planting fruit trees

The cost of planting itself again consists of material and labor costs and is approximately 1: 1. In addition to the trees themselves, it is necessary to include the price for the support sticks, mostly bamboo, or other fixing material, and we also include the price for the seed for greening the soil between the rows. We then include in the price for the planting itself all actions related to it, e. G. transport and distribution of trees, digging of pits or gutter, planting itself, watering, distribution and installation of support pins, fixation of trees to them, sowing of seeds and pruning after planting if planned. The total amount for planting itself is influenced by a number of factors, especially the price of trees, but is generally at the level of 17 – 20000,-EU/ ha, which represents about 22% of the total costs.

Establishment of support system

A modern intensive spindle-shaped orchard also needs a supporting system, preferably with the installation of anti-hail nets. Due to the current frequencies of this meteorological phenomenon, its installation is becoming a necessity. At the same time, it also serves as protection against sunburn, which has affected the fruit relatively often in recent years. The costs include material and labor, they represent about 21% of the total costs and, depending on the type and design, are priced at the level of 15 – 20000,- EUR/ha.

Fig. 18. A modern intensive fruit orchard needs quality support system (Spinazze/Wiesel/Fruit Security). (photo: Mezey)

Construction of irrigation system and retention water reservoir

Building a high-intensity spindle-shaped orchard without irrigation is unthinkable. This has been confirmed by other years. If we look at the characteristics of years in terms of temperatures and precipitation, they are usually normal, but if we look at the characteristics of individual months, we come across extremes. A nice example is the year 2016, when the dry and wet months alternated almost regularly. Of course, these fluctuations are not good, because woody plants, and especially shrubs, need a regular supply of water, and we need to compensate for these extremes with additional irrigation. There are many similar examples.

Installing an irrigation system in intensive orchards is essential. The total costs per hectare for drip irrigation is, depending on many circumstances, at the level of 12-15000,-EUR, which does not include the construction of a well and the relevant pump, because it is very individual. As a percentage, irrigation costs make up about 16% of the total costs. The costs include items for the filter station, automatic valve control, irrigation distribution, fertigation system and labor costs.

A separate item is the anti-frost protection system, which is currently proving to be the most effective way to protect plantings against late spring frosts. In addition to the costs themselves, which are at the level of 17 – 20.000,-EUR/ha, it is necessary to realize that this system needs a huge amount of water at one time, which most wells cannot supply. For this reason, the construction of a retention water reservoir is often included in the project. It is basically a pond and does not form a large item; it is usually up to 5% of the total cost. Nevertheless, it is necessary to build it with high-quality compacted substrate, geotextile, as well as the pond foil itself. Special tanks designed for this purpose (Genap type) are a more suitable alternative to the pond, because they are covered from above and algae formation is prevented. The size depends on the irrigated area, but especially whether it will also be

used as an anti-freeze system. The need for water for antifreeze irrigation is 2 – 4 mm/hour/m^2, which in hourly operation represents a volume of 20 – 40 m^3 of water per ha per hour. We run the irrigation just before the frosts and the water supply must be continuous throughout the frost, which is sometimes 4-6 hours. Subsequently, according to this, we calculate the water demand and choose the size of the retention tank. E.g. with 6 hours of system operation, the need for water per ha is 120 – 240m^3. If we do not consider anti-freeze irrigation, the tank is not necessary, but we still recommend it, also due to the possibility of using this system as an air-conditioning irrigation against sunburn.

Items that the investor often does not think of, do not constitute significant costs, but they must be taken into account. These include e.g. harvesting bins of various sizes and shapes. Their number must be calculated according to the expected harvest and it is good to calculate them from the beginning. As a percentage, we are somewhere at the level of 5 – 15%, where the most expensive items are bigboxes. When converted to kg of fruit, they are priced at 0.4 EUR/kg, while e.g. the classic "green" crate costs 0.2 EUR/kg.
More pricy items include mechanization and machinery and it is also possible to procure the mechanisms used. The minimum equipment and price relations for second-hand machines are listed in Table 9.

Tab. 9. Average prices of used mechanisms and machinery necessary for the operation of the orchard.

Item	**Price in EUR**
tractor 30-50PS (used)	15000
sprayer, volume 300-600l (used)	4000
mulching machine, scope 1,53m (used)	2000
single axle flatbed semitrailer, capacity 5t (used)	1000
cultivator, coulter, with swinging arm (used)	2000
total	**24000**

Other, though not investment items, include annual orchard costs. Here the costs are very individual and depend on the number of sprays, their type and character, frequency of use. Labor costs must also be calculated. It is therefore difficult to define average annual costs in general, but e.g. application of standard spraying program for IPM in the number of 11 sprays, where 4 applications of fertilizer per leaf are included, as well as work for application, mulching and pruning is based on approx. 2000 – 4000,-EUR/year/ha.
In addition to all the items mentioned, for the proper functioning of the planting, it is necessary to provide many other requirements that are closely related to the subsequent operation of the orchard. These include e.g. energy costs, water, fuel, labor costs, contributions to insurance companies, transport, and construction of service roads, warehouses, sorter, packaging, shipping, marketing, advertising and much more.

Tab. 10. Average cost of establishing 1ha of intensive orchard.

item	**cost (material+labor) (EUR)**	**cost (material+labor) (%)**
Soil preparation	4.000 – 5.000	5
Outplanting	17.000 – 20.000	22
Fencing	7.000 – 10.000	9
Support system with antihail nets	15.000 – 20.000	21
Drip irrigtion system	12.000 – 15.000	16
Antifrost irrigation	17.000 – 20.000	22
Retention water reservoir	4.000 – 5.000	5
total	**77.000 – 95.000**	**100**

GROWING TECHNOLOGIES FOR THE PRODUCTION OF INDIVIDUAL FRUIT SPECIES

As the currently most preferred growing shape is the slender spindle and its modifications, the information on pome- and stone fruits will mainly concern this shape. If you are interested in other forms of cultivation, which, however, are among the less economical from a large production point of view, it is possible to obtain this information from older literary sources.

PRODUCTION TECHNOLOGIES OF APPLES

Apples are the most cultivated fruit species of the temperate zone not only in Slovakia in the Czech Republic, but also in fruit growing areas in Europe. The apple tree was the first fruit species in which the slender spindle shape was successfully used, mainly because there was a suitable weak-growing rootstock. Its advantages include low soil and climatic conditions, plasticity to cultivation area and soil types. It also tolerates heavier and infested soils, does not suffer from asfixation. Most varieties do not show strong apical dominance and are one of the most suitable species for spindle shapes. They are very willing to form enough shoots with a appropriate angle from the central axis and very willingly differentiate even with less light intensity. They bear mainly in the middle part of the shoots; there are only a few varieties that bear on long wood (at the end of shoots). However, we do not recommend these varieties for the shape of the slender spindle. They enter bearing very early, often the second year after planting, or, in case of knipp-trees even in year of planting. We get the best fruits on two- to three-year-old wood, while they also bear fruit on 4 to 5-year-old wood, but the quality of the fruit is not satisfactory. The lifespan of apple trees in the shape of a slender spindle is 12 – 15 years in large-scale production; in gardens it is limited to about 15 – 17 years.
Spacing for apple trees varies depending on the shape used. In the case of dwarf-stem, we usually choose 5 – 6x3 – 4m spacing. 3.5 x 0.8 – 1.2 m is a very common spacing for the spindle.

Fig. 19. The slender spindle is currently the most widely used growing system with various modifications. (photo: Mezey)

Suitable growing locations
The most suitable areas for apple growing are locations up to 350 m above sea level, with the possibility of growing some varieties up to 500 m above sea level, but with restrictions for late ripening varieties. The optimal average annual air temperature is 8°C, 600 – 800 mm of precipitation per year. Medium-heavy alumina-sandy or nutrient-rich sandy aluminous soils with a pH of 6.2 – 7.5 are suitable. On heavier soils, tree growth tends to be slower in the first years. Stony, shallow soils with high

groundwater levels are unsuitable. Slightly hilly and undulating habitats are suitable, the southern slopes, too warm and dry areas are less suitable, as well as closed basins with a small air flow. In areas where late frosts are frequent in early and mid-May, we do not recommend growing apple trees on plains where cold air has nowhere to flow. Frost damage reaches 70% in extreme cases.

Suitable rootstocks

The basic condition for growing apple trees in the shape of spindles is the selection of rootstocks. For intense low-stem forms of slender spindles, we choose weak to very weak-growing rootstocks. Currently, the most widespread and most plastic in terms of growing conditions is the M9 rootstock and its clones (T337, T339 and Carolina). Another condition is the virus-free nature of the planting material. Of the other spindle rootstocks the M26, M27, J-TE-E, J-TE-F, J-TE-G, J-TE-H and other rootstocks are also suitable, but absolutely satisfactory results are achieved on the virus-free rootstock M9.

Suitable varieties

A very important criterion for growing apple trees in the shape of spindles is the selection of suitable varieties. For simplicity, the varieties can be divided into two groups. Varieties bearing on long wood and so-called spur-types, i.e. varieties that form clusters of fruit on short fertile wood mostly in the middle part of the shoot. Since we strive for a compact shape with shorter shoots when shaping the spindles, there are no varieties bearing on long wood, resp. at the end of the shoots suitable for spindle shapes. Unfortunately, there are also popular varieties among them among gardeners, such as Rubin, Melodie, Bohemia etc. A certain solution for these varieties is the use of pruning in the summer with the use of special pruning techniques, which are on the other hand due to time-demand not usable in professional orchards. With other varieties, there should be no problem in terms of creating bearing wood.

Another important criterion in the selection of varieties is their ripening date. From this point of view, apples are divided into three groups: summer, autumn and winter varieties. From a practical and logistical point of view, it is important to know in what proportion they should be represented in the plantings, resp. gardens. Summer varieties should be about 10% represented autumn varieties 20% and the remaining 70% should be winter varieties. Therefore, if we plan to plant e.g. 10 trees, so one variety should be summer, two autumn and 7 winter varieties. This is because the summer and autumn varieties cannot be stored for a long time or at all, they need to be consumed by the arrival of winter. Winter varieties can be re-stored in domestic conditions until Easter at suitable storage areas and appropriate harvest dates. In professional warehouses with a controlled atmosphere, apples can be stored until the next harvest.

Of the early (summer) apple varieties, we recommend Galmac, Initial, Piros, varieties, which are resistant to apple scab and tolerant to apple powdery mildew.

Of the autumn apple varieties, it is mainly Gala and its clones, especially the Schniga / Schnitzer / Schnico clone, but also the newer Simmons / Buckeye, Gala Decarli fendeca and Galaval clones, which have a high market value. Of the other modern autumn varieties, these are e.g. Honeycrisp, Antares and Daliclass.

Fig. 20. Calibration measurements for different apple varieties by the end of August. (photo: Mezey)

From the group of winter varieties, the Golden Delicious variety and its clones (Smoothie, clone B, Reinders, Golden Parsi, Pink Gold and others) are the mainstay of plantings. Late varieties such as Fuji and its clones Kiku 8, Fubrax, King Fuji, SAN-CIV and Raku-Raku are suitable for areas with longer vegetation. The Braeburn variety and its Hilwell and Mema clones are already in decline in modern fruit growing. The Granny Smith variety and especially its Challenger clone hold a stable place. Evelina, who regularly receives the title Apple of the Year, is a valuable clone of the Pinova variety. Czech varieties Rubinola, Topaz and Red Topaz. All previous varieties are grown also in abroad, as well as local varieties of local importance.

Club varieties create a special group. They are new varieties or clones promoted in terms of marketing and are licensed and marketed under their own brand in only limited quantities and have their own marketing strategy. They are about 30% more expensive. These include varieties such as Kanzi, Evelina, Pink Lady, Jazz, Sweet Tango, Kiku 8, Golden Orange, Lucy, Opal, Pink Gold etc.

From the new generation, especially high-quality Czech varieties, we recommend the varieties Luna, Opal, Lipno, Orion, Rozela, Admiral, Merkur and Shalimar, which are resistant to scab and resistant to powdery mildew.

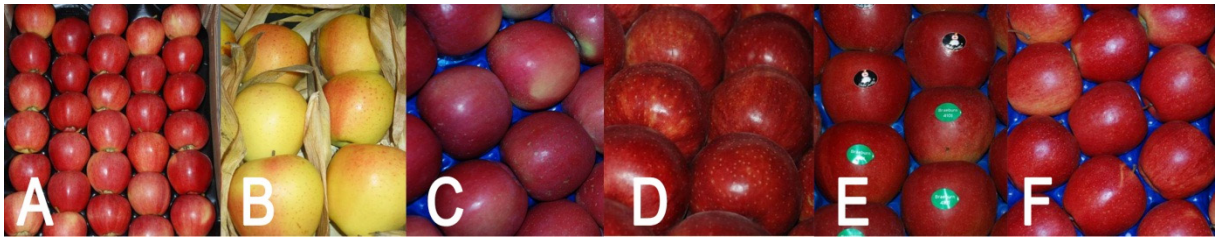


Fig. 21. A – Gala Schniga/Schnitzer/Schnico, B – Golden Delicious Pink Gold/Golden Parsi, C – Fuji Kiku 8/Raku-raku, D – Jonagold Novajo/Dacosta, E – Braeburn Hilwell/Mema, F – Pinova Evelina. (photo: Mezey)

Specifics of growth, pruning and training

The growth of apple trees is very suitable for the shape of a slender spindle due to its moderate apical dominance. When using week-growing rootstocks, the splitting of bearing wood along the entire axis of the central leader is even, this is ideal for this shape. In some varieties, the growth of shoots in the upper part is dazzling, which can be managed with summer pruning or pinching of shoots.
By pruning and training we must think of the final shape of the tree, which only with proper training and treatment will allow full use of the physiological principles of growth and fertility on which this shape is built. The goal is to grow a 2.5 – 2.7 m, but also 3.5 m high trees, on which are placed in a more or less regular spiral semi-skeleton branches. On these there is a shorter and longer bearing wood. The tree should retain its pyramidal shape throughout its life, allowing it to perfectly capture sunlight.
Since the best fruits are on wood from 2 to 3 (-4) years old, the pruning should be focused on maintaining and obtaining as many such branches as possible, while adhering to the laws of growth and bearing. It is equally important to ensure a sufficient number of one-year-olds, on which the differentiation of flower buds that will bloom the following year will take place. We can make the selection of shoots already within the summer cuts, when we leave the shoots that grow outwards from the crown and have more or less growth close to the horizontal.
They respond very well to dormant and summer pruning, they do not suffer from sap-flow after major interventions. They have a good regenerative ability and respond very well to the gradual rejuvenation of 4 – 5 year old wood by pruning into twisted-stalks.
The sprouting of sleeping and adventitious buds after larger interventions is very high, so we recommend treatment in the form of breaking out the shoots in the summer. By breaking out the shoots, we also remove part of the bark with these buds and the formation of water-sprouts, resp. regenerative shoots is not so strong.
By pruning and training it is important to ensure adequate dominance of the central leader in the first years, as well as the vitality of the lowest branches, as well as the balance between growth and bearing. We must not allow the transformation of built branches into skeletal ones by following Zahn's rule.

Fig. 22. Licensed and high quality varieties Fuji SAN-CIV and Opal. (foto: Mezey)

Supporting structure
In the case of apple trees, a support system is necessary for this shape due to the very weak root system, especially on the M9 rootstock. In the first years, cultivation without construction is possible, but with the onset of full fertility, trees tend to lie down due to crop overload, the central leader deforms, does not fulfill its purpose, the growth of competitive shoots begins.
The modern support system consists of pre-stressed concrete columns of various diameters depending on the function of which column and a length of 4.50 – 4.70 m. These poles are installed at a distance of 5 – 6 m to a depth of approximately 0.5 – 0.7 m. In this case, the wire is stretched on 3 – 5 floors. The wires need to be sufficiently tensioned and checked at the beginning of the season and also during

the growing season. We then fix the tree to the wire with a special clip anchor. Usually, the system is built so that it is possible to install anti-hail nets, or foil cover against excessive rain respectively.

Irrigation

When irrigating, it is important to be aware of the fact that the root system is relatively shallow in the soil. The main mass decomposes at a depth of 0.3 m and it is necessary that the soil is permanently moist (not wet) at this depth. If the soil dries up, the hairy roots, which only ensure the intake of water and the assimilates soluble in it, dry out, the growth stops, the tree comes under stress and, depending on the length of the dry season, it takes several days to weeks for growth to resume. It is therefore very important to pay attention to the correct irrigation regime and soil moisture regime.

For apple spindles, it is important to ensure sufficient moisture even before flowering, if it was a dry winter and spring. The demands are increased even after flowering and at the time of tying and setting the fruit, which is approximately before the fall of the fruit in June. With this dose, we will improve the differentiation of flower buds and reduce the fruit fall in June. The next stronger irrigation dose should be given in the period after the fruit fall in June, during the intensive growth of the fruit. We apply the last increased dose in the period before the fruit is harvested, but no more than 3 weeks before the harvest. If we irrigate after this deadline, we risk the long-term storage of the fruit. Apples are larger, but the length of storage is reduced. In large-scale orchards a computer-based drip irrigation is used.

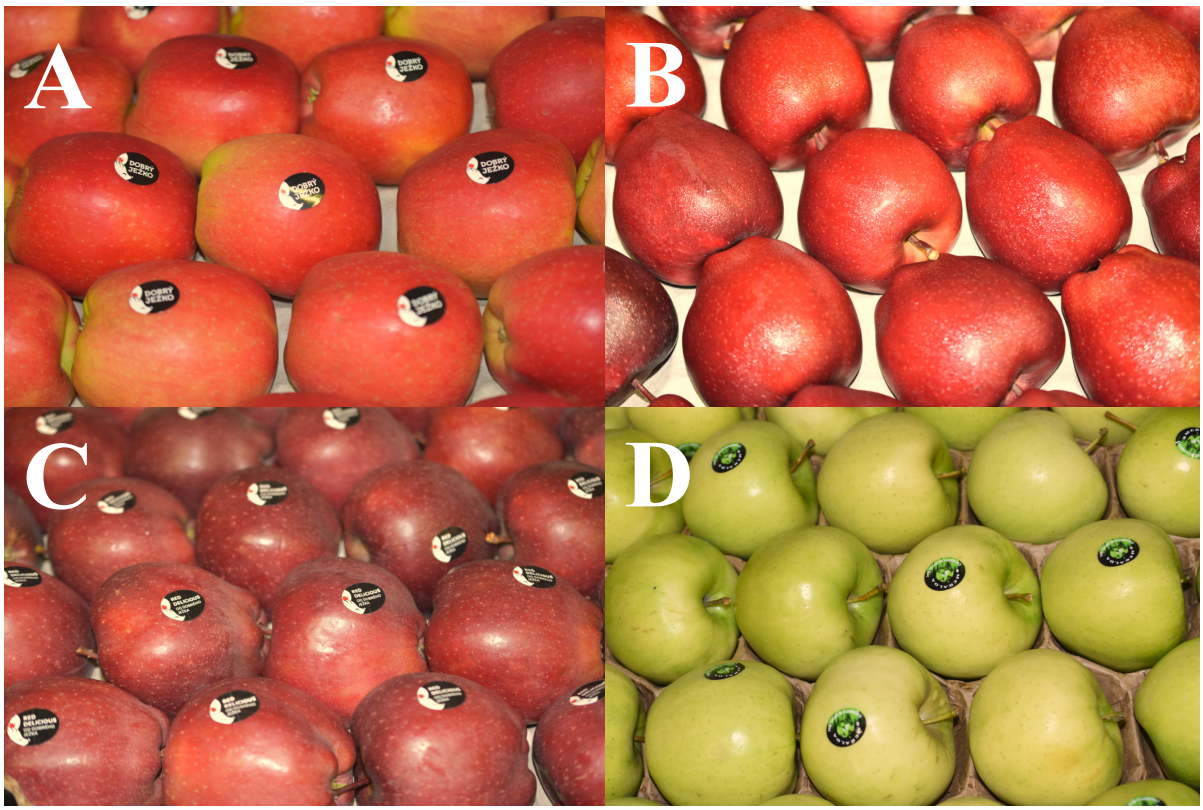


Fig. 23. Commercially valuable varieties: A – Fengapi, B . Jeromine, C – Red Delicious, D – Smeralda. (photo: Mezey)

PRODUCTION TECHNOLOGIES OF PEARS

Pears are the second fruit species after apple trees, which have successfully adapted to the shape of a slender spindle. Apical dominance is much stronger in this species than in apple trees, but by selecting a suitable week-growing rootstock and in combination with a system of pruning and training, this shape has also successfully established itself in large-scale production. Due to the nature of the growth, a higher overall height of the shape is suitable in comparison with apple trees, when it is possible to grow them up to a height of 2.7 – 3.0 m and in the case of a reinforced and increased supporting structure up to a height of 3.5 m.

Suitable growing locations

Pears require slightly warmer locations than an apple tree. Soil requirements are similar to apple trees. The northern slopes do not suit them, protected (from wind, late spring frost) areas are very suitable. The average annual air temperature should be 8°C to an altitude of 300m.n.m. at an average annual rainfall of 450 – 600mm. As pears are relatively sensitive to severe frosts, we recommend growing them in places where frosts around -20°C do not occur for a long time. They are suitable for medium-heavy sandy-loam, loam-sandy soils, sufficiently permeable.

Suitable rootstocks

For week-growing and low-stem spindles, we recommend new clones of MA and MC quince, which no longer have an affinity problem. For Asian pears (so-called nashi), the rootstocks of the common pear (*Pyrus betulifolia*) as well as the seedling of the common pear are suitable.

Suitable varieties

The assortment of pears does not have an intensive influx of new varieties, which would be suitable for large-scale production, so the assortment is relatively the same, such as ten years ago. In general, unlike apple trees, they bear pears almost exclusively on short wood, so problems with shelling are less common. This is due to the different nature of the native growth than the apple trees.

Like apple trees, it is possible to divide pears into three groups according to ripening, namely summer, autumn and winter varieties.

Of the early, summer varieties, Williams and Clapp are suitable. Of the autumn varieties, we especially recommend the Conference variety and its clones. Of the winter varieties, the best varieties are clearly Dicolor and Bohemica, Qtee, Fred but also varieties such as Abate Fettel, Grafin von Paris, Erika, Lucassova, Vonka. From the assortment of Asian pears, it is possible to plant all varieties that are available in nurseries.

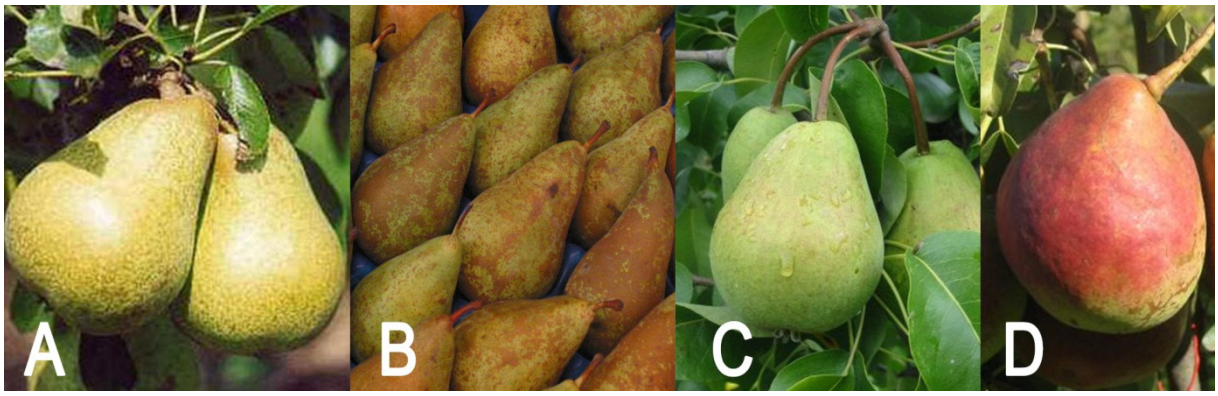


Fig. 24. A – Williams, B – Conference, C – Bohemica, D – Dicolor. (photo: Mezey)

Specifics of growth, pruning and training

The biggest problem with pears is its apical dominance, which can be overcome by apropriate training measurements (bending and tying the shoots to a position close to the horizontal) or sectorial double pruning. If apical dominance is not treated, we get shapes and shoots that are naturally almost perpendicular, show strong growth and almost no bearing. In addition, such branches are very prone to breakage. Pears have a much more fragile wood than an apple tree, so it is necessary to be extremely careful when bending the shoots to avoid damaging the shoots. A very suitable measure is to dilute unnecessary shoots by breaking out in the summer. A slight weakening of growth can be achieved by sawing the trunk. We make the number of notches depending on how we need to weaken growth.

The procedure for growing pear spindles does not differ significantly from the cultivation of the shape and further care from the cutting and shaping of apple trees.

Fig. 25. Pear as slender spindle. (photo: Mezey)

Support system

Rootstocks used for pear spindles also show weak growth and weak anchorage, which is why the construction of a supporting structure is almost a necessity. In addition, relatively heavy fruits, especially on young trees, cause unnatural bending of shoots and inhibition of vegetative growth, which is also needed to ensure sufficient shoots for next year.

Since the pears have fragile shoots which could break due to extreme bending, the lower floor of the wire rod is suitable to be guided by means of two guide wires which are spaced about 0.5 m apart and are guided through the eyes of an iron profile which is fixed to the support rope. Another wire runs through the center of the support rope. In this way, it is possible to bend and fasten the shoots without the risk of breaking them.

We adjust the total height of the structure to the total height of the tree. However, the classic construction with three floors 0.6m apart is sufficient.

Fig. 26. Two- wire support system used by pear spindle. (photo: Mezey)

Irrigation

In watering pears, the same principles must be followed in practice as when irrigating apple trees.

PRODUCTION TECHNOLOGIES OF PLUMS

Plums are one of the fruit species that have begun to be grown in the shape of a slender spindle in past 10 years. The absence of spindles was caused mainly by the relative satisfaction with the heights and quality of the crops by dwarf- or quarter stems, and in the case of industrial processing, the fruits from the half-stems were also sufficient. The market was dominated by industrially processed fruits.
With the arrival of new generations of varieties of German new breeding, people's interest in plums for direct consumption also increased, which were declared as resistant to the plum pox virus (sharka), which decimated plantings not only in Slovakia and could not be defended against it. Very attractive and high-quality varieties have come to the market and are still coming, which enjoy the interest of large-scale production, but also of small growers, and only exceptionally show symptoms of PPV. The myth of the Bystrická variety (Hauszwetschke) was also overcome, as the opinion that it was unsurpassed in taste has long prevailed. Currently, there are plenty of varieties that are tastier and better.
At the moment, it is possible to arrange the plum varieties so that we receive yield from about mid-July to almost the end of October. At the same time, weak-growing plum rootstocks have entered the market, where all crops can be harvested comfortably from the ground, and what is a huge advantage over stronger rootstocks is that weak rootstock growth is very effective in dampening even very strong apical plum dominance.

Suitable growing locations
Plums are generally more suitable for higher and colder growing locations, but of course they can also be grown successfully in southern and warm areas. They like deeper, clay soils, reasonably moist with a groundwater level of up to 0.8 m. For intensive plantings, the maximum altitude is up to 350 m a.s.l., in smaller gardens it is possible to grow them up to 600 m, at an average annual air temperature of 7-8°C and an average annual rainfall of 500 – 700 mm.

Suitable rootstocks
For low-stem shapes of the spindle types, the St. Julien A is suitable, which we recommend for poorer and wetter soils, but also the selection of low-growing myrobalans (MY-BO-1), as well as the S-BO-1 rootstock, which is also suitable for higher cultivation locations and wetter soils.
Torinell is a very suitable rootstock for warm areas and nutritious soils. The weakening of growth compared to plum seedling is up to 55-60%, it has a good affinity with modern varieties,
fertility is early and begins in the third year after planting. The rootstock also tolerates wetter and heavier soils, has higher resistance to asfixation. Its disadvantage is the creation of a larger number of excavations from roots. Entry into the vegetation is slower, the trees on the Torinell rootstock need a higher soil temperature to start the sap flow, which is advantageous in terms of escape from late spring frosts. But we really only recommend it to the best and warmest areas.
Similar features are created by selection from a Wangenheim plum called Waxwa and Wawit. One is propagated generatively and Wawit is propagated in vitro. The varieties on these rootstocks have a very weak growth, the reduction in growth is up to 50% compared to the seedling. Entry into vegetation is slower, they need a higher soil temperature for sap flow, similar to Torinell. However, it does not form so many excavations. On dry and sandy soils, it has the disadvantage that it does not form a sufficiently high-quality fertile growth.

Suitable varieties
We no longer recommend the Bystrická variety, which has not been surpassed for a long time, because it is extremely susceptible to the PPV. Unfortunately, the healed clones of this variety are no longer produced, so most of the planting material is more or less infected with viruses, which in addition to a reduction in sugar content and fruit size weaken the assimilation capacity of the tree which subsequently shows signs of chlorosis and general wilting of the tree.

Varieties from the breeding station in Čačak in the former Yugoslavia are also behind the zenith, although some growers prefer them. It is therefore possible to plant the Čačanská Lepotica and Valjevka for direct consumption and the Čačanská rodná and Čačansská najbolja for distillates from the Čačan varieties.
From the huge group of German new breeds that are tolerant to the sharka virus, it is possible to grow varieties ripening in late July at the beginning of August, varieties Juna, Colora, Katinka, Tegera, Tipala, Topfive and Topper, from medium-late ripening varieties Topking and Felsina. Varieties ripening in late August, early September are Haroma, Hanita and Tophit and late ripening varieties such as Elena and Jojo, and extremely late ripening variety Top 2000, or Topend plus, ripens 8 – 10 days after the variety Elena, i.e. early October and is suitable for storage. Currently, however, the biggest hit is the Toptaste variety, which is due to its very high sugar content suitable for both direct consumption and distillates. The Stanley variety is a classic that will not disappoint.

Fig. 27. A – Katinka, B – Tipala, C – Jojo, D – Top 2000 (Plumtastic). (photo: Mezey)

Specifics of growth, pruning and training
Apically dominant plums are characterized by predominantly strong growth and development after planting, a tendency to form small tilt angles and forked branches. The wood is fragile and improperly placed branches break easily. Due to the fact that the fruits are often attacked by moniliosis, it is necessary to remove branches with mummified fruits during pruning. Another characteristic feature is the rapid thickening of the crown, which causes the bearing wood inside the crown to dry out and a sap-flow may occur. Over-densing of the crown is a characteristic feature especially in the first years after planting.
The nature of the fertility of individual groups of plums is very different, some have a predominance of fertility on annual wood (Asian and American plums), others give birth more on short-flowered to flowery branches (European varieties), to which we must adapt the pruning.
For plum spindles it is possible to successfully use spacing similar to apple trees, for gardens it is 3 – 3.5x1.5 – 2.0 m with a trunk height of 0.4 – 0.6 m and a total tree height of 2.3 – 2.5m, but it is possible to grow "wider" spindles, when we plant trees at 2.5 – 4.0m and between rows of 3.0 – 5.0m.
Plums are similar to pears, fruit species with strong apical dominance, so it is necessary to treat shoots that are strong and grow almost vertically. A very suitable measure is bending and tying the shoots to a position close to the horizontal. A suitable measure is also to pinch 6-8 buds under the terminal bud, which will weaken the apical dominance and support the formation of shoots with a blunt angle of growth from the central leader. Similarly, this growth direction can be achieved through a sectorial double-pruning. Success depends on the chosen rootstock, the weaker the growth, the better it responds to this way of training.

Support system
As with previous species, the plum rootstocks show weak growth and low anchorage, which is why the construction of a support system is necessary. Even by plums, the high fruit set in the first years causes bending of the shoots and inhibition of vegetative growth, which is also necessary to ensure sufficient shoots for next year.
We adjust the total height of the structure to the total height of the tree. However, the classic construction with three floors 0.6m apart is sufficient.

If we choose a system of wider spindles, a supporting structure is not necessary, but it is necessary to choose a stronger support such as Torinell, Wawit and Waxwa.

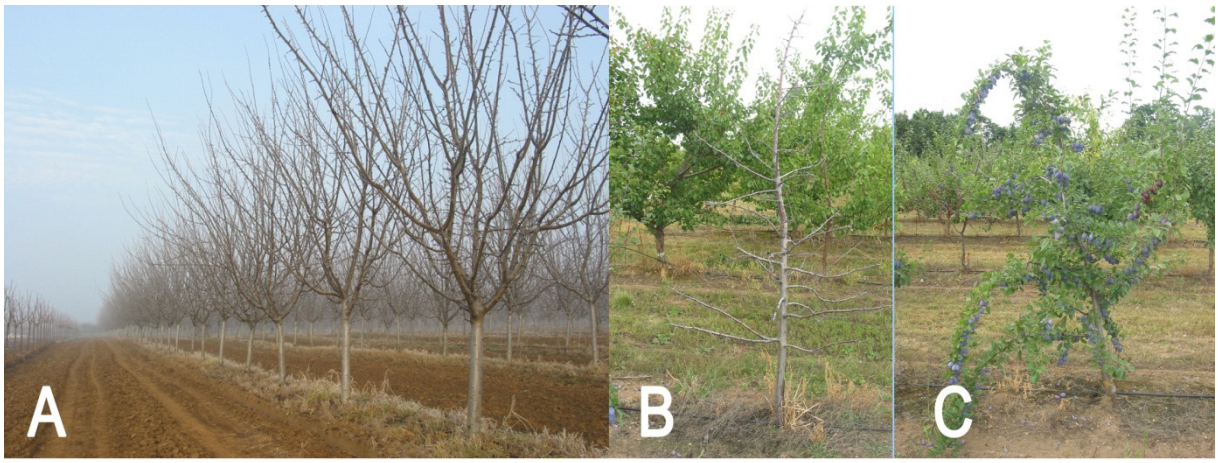


Fig. 28. A – Quarter stems by plums are suitable for mechanical harvest, B and C – one of the modifications of the shape of a slender spindle. (photo: Mezey)

Irrigation

Like all young trees, plums need to be irrigated, especially in the first years of growth, before they reach fertility. In the case of fruiting trees, the first critical period of irrigation is the period before flowering, the second is after flowering, in the period after pollination, and the third critical period of moisture demand is from the beginning of pit hardening and during intensive fruit growth.

PRODUCTION TECHNOLOGIES OF APRICOTS

The spindle of apricot was only recently introduced. This was due, as with plums, to an outdated range of varieties and the absence of suitable week-growing rootstocks. There are many modern varieties on the market today with a huge flower set and quality fruits. The difference compared to the previous species lies in the different type of spindles used in apricots. Rather, wider types of spindles with an established lower floor are used, which form the skeleton of the entire shape. A support structure is not necessary in this case.
When choosing spacing, we take into account the growth of the rootstock, for week-growing rootstocks, spacing in the range of 3.5x2.0m or experimental buckles of 3.5x1.0m are suitable, which proves to be very suitable if there is a higher tree decline at the given site. Theoretically, if we had even a 50% outfall, there are always as many trees on the area as on the site without an outfall in a 3.5x2.0m clip. The total tree height in both cases is 2.5-2.7 m.

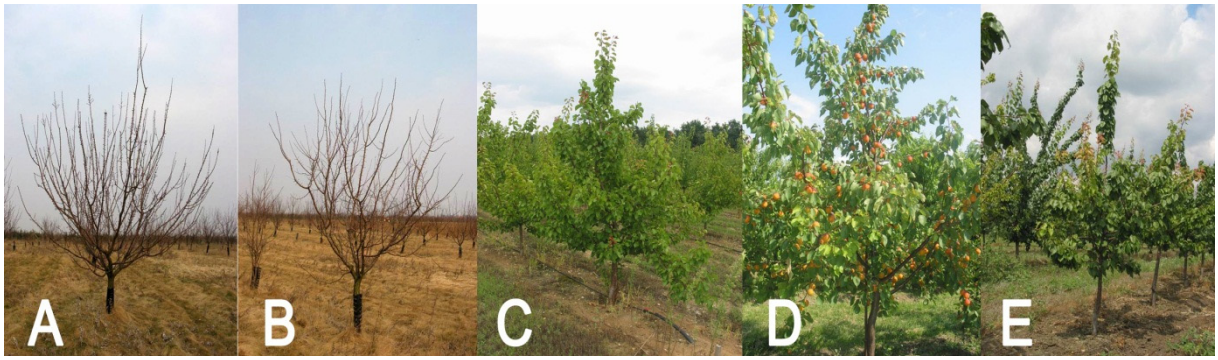


Fig. 29. A, B – older apricot orchards were estabilished as quarter-stems, C – apricot dwarf-stem, D, E – apricot spindle and its modifications. (photo: Mezey)

A common problem of recent years is the complaints of growers (professional or hobby), that apricots do not last long on the site and after a relatively short time (6-8 years) there is a more significant tree drop-out. Many attribute this to the poor quality of the modern varieties and argue that the old varieties do not do this. In part, they are right, it is also related to modern varieties. We see the reason for this condition in the fact that the modern varieties of apricots produce a huge number of flowers, most of which are pollinated and fertilized. However, if the flowers or the fruita are not thinned and remained on the tree and gradually over the years, the tree becomes weaker and later dies. The solution is to make flower- or fruit thinning, especially on young trees. As the most suitable, we recommend thinning flowers from the white bud stage to full bloom by manually rummaging through a flowering branch. Another option is to use rotating rubber bands that embrace flowers (Darwin). The classic chemical thinning with standard substances has not proved successful, there is excessive burning of flowers, so alternatives in the form of wetting agents are being tested. In any case, we recommend fruit thinning for apricots.

Suitable growing locations
Apricots, together with peaches, are among the most demanding species in terms of temperature in moderate climate zone. For this reason, we plant them only in the warmest localities with an average annual air temperature of 9°C up to an altitude a.s.l. of 300 m with an annual average total precipitation of up to 600 mm. In higher growing areas, they very often suffer from frosts, especially when flowering. They require lighter and permeable soils. They are sensitive to groundwater levels and lack of soil air can cause asfixia (death of roots due to lack of air), so heavy soils are not suitable. It is very important that the growing area is not closed, as there is a risk of late spring frosts. Slightly sloping positions are optimal, in the warmest positions up to 200 m a.s.l. also the northern and northwestern slopes. On such slopes, the onset of vegetation is slower, but that is why apricot

blossoms escape the late spring frost. The plains are not very suitable, because there is nowhere to run cold air from them and plantings on the plains are very often affected by late spring frosts.

Suitable rootstocks

For the tall spindles of apricots, Rubira, Montclar and BSB 1 rootstock appear to be the most suitable and universal to site conditions. They are a selections from peach seedlings, but are also suitable for apricots. Montclar and BSB 1 rooted a little deeper than Rubira. Both weaken the growth of grafted varieties. While the trees on Montclar rootstock reach about 80% of the height of the trees compared to the seedlings, the Rubira rootstock reduces growth by 30% and the trees reach about 70% the size of apricot seedlings. They are also very suitable for lighter, drier and less nutritious soils, on the contrary, they are unsuitable for heavier soils, clayey, wet and cold soils. They are also unsuitable for soils with a high $CaCO_3$ content, where in addition to chlorosis there is also a poorer affinity with grafted varieties.

For the best soils and a tree height of 2.5 m, we recommend Torinell and Wawit. In the case of apricots on nutritious, high-quality soils, Torinell is becoming the most important support for slender spindle apricots. The rootstock has weaker growth than GF 655/2 and is suitable for asfixed soils. It forms less excavation and has good affinity with all varieties of apricots. The positive is a higher specific and very early bearing. This means that the yields per tree are high and in some cases we receive the fruit in the second year after planting. It is tolerant to nematodes and soil fungi. However, it requires warmer soils to overwinter, then the sap flows earlier (similar to WaxWa, Ishtara, Jaspi and Pumiselekt). We recommend soaking the roots in water before planting. However, if we put this rootstock in worse or lighter soils, growth and fertility will not be satisfactory, and after a few years, trees may fall out.

Wawit rootstock is a selection from Wangenheim plum seedlings and further propagated in-vitro conditions, so it is absolutely homogeneous, which is a great positive and a guarantee of quality and balanced material. Growth is even 10% weaker than Torinel. We also recommend it only for the best and strong soils, where it appears to be the best support for spindle-shaped, intense, low-growing shapes. It is resistant to asfixation and chlorosis and trees have a long life. They have good affinity with all important varieties. Fertility is early. It is plastic for habitat conditions.

Selections of plum rootstocks appear to be the most universal rootstocks even in worse, slightly skeletal and heavier soils. Julien A, resp. St. Julien 1 and Adesoto. The reduction in growth is about 50% compared to the seedling and the Adesoto rootstock also tolerates drier and more calcareous soils.

Suitable varieties

Of all the fruit species, we are experiencing the fastest assortment variation in the case of apricots, even at intervals of 5 – 7 years. This situation is caused by the huge interest of consumers in this type of fruit, especially in France, Spain and Italy. In addition to classic breeding stations, fruit nurseries are also bred using DNA markers, which place a number of high-quality, licensed (club) varieties on the market. When buying, the license for the variety and in some cases for the rootstock is then added to the basic price of the tree. The license fee is usually at the level of 2,0 – 3.0,- EUR/pcs.

The variety Hungarian best has long been the standard and similar was the Sabinovská and Veľkopavlovická varieties, which have similar characteristics. From the Slovak breeding, which was focused on a longer flowering period, thus preventing the complete loss of flowers due to late spring frosts, were the varieties Veharda, Vesna and Velbora. At the moment, however, they have been surpassed by modern, especially French, varieties.

While the early varieties Pinkcot and Sylvercot ripening at the end of June appeared to be of the highest quality in 2010, there is currently no interest in them due to insufficient fruit color, consumers demand more red on the skin. Earlier varieties that ripen in early June are currently in high demand for the Tsunami and Spring Blush varieties, while the Aurora variety is no longer of interest due to the consistency of the flesh and the color of the fruit. Of the medium-late varieties during the month of July, Bergeval and Sefora varieties appear to be promising. The Orangered (Bhart) and Bergarouge varieties are still suitable, while the Goldrich variety, which has enjoyed great interest, is no longer

attractive because of its color and, above all, its higher acid content. This ailment can be alleviated by about 10 days of storage, during which the acids break down and the taste is more acceptable. At the end of July, the Anegat variety ripens, which is very attractive for consumers.
Of the varieties that ripen in August are suitable e.g. Bergeron, Fantasme, or Tardicot at the end of August, which, however, has relatively upright growth and hardwood, requires a firmer and tighter hand in sectorial double pruning techniques, the need for a summer pruning if necessary, as well as twice. After the onset of full fertility, the growth will calm down and we have apricots at the end of August, which was not the case in the past.

Fig. 30. A – Hungarian best, B – Aurora, C – Sylvercot, D – Orangered. (photo: Mezey)

Thus, modern varieties of apricots can cover the whole summer from early June to early September. As an example, these varieties can be planted with ripening from the first week of June to the first week of September, depending on the weather: Tsunami, Bergeval, Sefora, Orangered, Anegat and Bergeron (Tardicot).

Fig. 31. A – Goldrich, B – Kioto, C – Bergeron, D – Tardicot. (photo: Mezey)

Specifics of growth, pruning and training
Apricots are characterized by rapid development after planting, shelling of branches due to intensive growth and subsequent lack of light in the inner parts of the crown, a tendency to form competitive shoots and forked branches. Typical is the formation of several generations of shoots during vegetation, susceptibility to attack by wood by pathogenic microorganisms, especially through wounds made outside the vegetation, parts infested by pathogens and left on the tree, and premature death of branches and whole trees due to insufficient adaptation to our conditions.

In some years, too high yields supported by the absence of thinning can lead to tree exhaustion and subsequent death of shoots. We traditionally make pruning during the budding period, in case of frost

even later and the summer pruning plays a big role. In sites where bacterioses such as *Pseudomonas* are widespread, we make a major incision in September instead in spring.
Like plums, spindle apricots can be grown with two spindle systems. Classic with a support system, without a lower auxiliary floor, or without a support system with an established lower auxiliary floor consisting of 4 – 5 branches arranged above each other and in space.
Embedding and subsequent pruning and training systems are no different from those used for plums. Similarly, it is necessary to guard the apical dominance, although it is not as pronounced as with plums. For apricots, the use of Shitt's cut has proved successful in the period up to mid-June, when the shoots will be shortened by ½ to 2/3, thus supporting richer formation of shoots in the salient shoot angles in the second growth wave, on which the flower buds differentiate and the following year the flower and fruit set is richer followed by weaker growth. It is advisable not to leave all the shoots created at this stage, but to choose the most suitable and remove the others.
They also respond very well to the sectorial double pruning, which we recommend especially for educational pruning. We cut thicker branches based on Zahn's rule during the dormancy period, because there is a risk of a light infection if we cut during the vegetation, which can also result in apoplexy (slaughter) of the entire tree.
In the period of educational pruning, it is absolutely necessary that in addition to dormant pruning we also make at least one summer pruning, optimally we make summer pruning two to three times, which seems like a lot, rather, full fertility is achieved. We treat both with Shitt's cut and the second stage of sectorial double pruning. After a series of summer incisions, the subsequent incision in the winter and pre-spring period is minimal and at the same time we significantly reduce the risk of bacteriosis infection, especially from the genus *Pseudomonas*. In some orchards, we introduced an apricot cutting system in September because of this disease, because chemical protection against bacteriosis is very complicated and often ineffective.
Another unconditional measurement until the third-fourth year after planting (but due to tree failure we recommend it every year) is the need to fruit thinning at the central axis at a distance of two fruits 15 – 20cm, especially in the upper third of central leader. If the thinning is not done, the central leader begins to bend under the weight of the fruit, creating an arc at the top of which water-sprouts begin to grow and at the same time strengthens the growth of side branches, which begin to take dominance over the central leader, the tree becomes stressed this imbalance is reflected in reduced flowering and fruit formation dynamics.
At present, when there is a problem with the workforce, pruning is coming to the fore with the help of disc cutters, with which we make a contour cut every year by the pink bud stage. The number of discs depends on the height of the crown. The advantage is also the possibility of picking fruit from the platforms, because by pruning we achieve that the trees form a wall. Seen from above, we get the shape of the crown, which is flattened compared to the classic spatial shapes. By regular pruning, we prevent older branches from shaving, because the growth is pressed towards the central axis every year.

Irrigation
As with plums, apricots need water, especially until full bearing. Subsequently, in dry periods, we can irrigate before flowering, after flowering and during the formation of fruit. The third critical period of irrigation is the period from the beginning of fruit hardening to the end of fruit growth and the fourth critical period after fruit harvest, especially for early and medium late varieties.

PRODUCTION TECHNOLOGIES OF PEACHES

Peaches, like apricots and plums, have been grown most often in the past as taller trees, because there was no suitable rootstock to weaken their growth and thus reduce the overall height of the trees. With the arrival of a new generation of French rootstocks in particular, this situation has changed and it is now possible to grow peaches in a low-stemmed way. It should be added that nevertheless, many new peach plantations are established in the shape of a hollow cauldron crown. The spindle peach can be successfully "let go" up to a height of 3 m and in a row choose a tree distance of 2.0 m. As for the shapes of the spindles, it is possible to grow them in the classic way as apple trees, ie without a weaker lower floor, but also as in the case of apricots, when we create a weak lower floor consisting of 4 – 5 skeleton branches arranged in space and above each other, following Zahn´s rule.

Suitable growing locations

Like apricots, peaches can be successfully grown only in the warmest localities of Slovakia, with an average annual air temperature of 9°C with an altitude of up to 200m a.s.l. and an average annual rainfall of up to 600m. Rather, they require lighter sandy soils with low groundwater levels because they are very demanding on the air content of the soil. If the soil is heavier and wet, the roots will die and asfixation will occur. They are also sensitive to the higher content of underground water level, and in the case of a longer-lasting condition, asfixation also occurs. As a precaution, we recommend leveling the soil perfectly on muddy soils and flat relief, so that there are no soil depressions in the form of deeper pits on the plot. The hills and gentle slopes are preferred. From this point of view, the relationship to the late spring frosts, to which peaches, like apricots, are very sensitive, is also very important. Therefore, we avoid the basins and partly the plains, from where there is nowhere to run cold air.

Fig. 32. Both apricots and peaches require permeable soils and plenty of soil air. If this is not the case, asfixation will occur. (photo: Mezey)

Suitable rootstocks

In the case of peaches, the most important criterion for selecting the rootstock is its tolerance to the $CaCO_3$ content in the soil and, based on that, the rootstock is chosen. In general, peach rootstocks tolerate the level of $CaCO_3$ until 5%, peach-almond hybrids up to 10% and over 10% almond rootstocks can be used.

A very suitable rootstock is GF-655/2, which weakens growth compared to peach seedlings by 20 – 30%. It has a shallow root system and is also suitable for heavier soils and is therefore more resistant to asfixation. It tolerates 8 – 10% $CaCO_3$ and shows good affinity even with nectarines.

The Rubira rootstock is also suitable for growing peaches in the shape of a slender spindle. It is basically a red-leaved peach seedling, which can also be used as an ornamental tree or shrub. It has good affinity with the varieties, the growth is moderately strong, so we recommend it either for light, sandy soils as a classic spindle to a height of 2.3 – 2.5 m, or for better and more nutritious soils, where it can grow to a height of more than 3 m. Despite being propagated generatively, the rootstocks achieve excellent homogeneity. It is more resistant to aphids. The fruits of the varieties planted on this rootstock reach a premium quality.

The rootstock Montclar is also very suitable for the shape of a spindle. It has a good affinity with the modern and also older varieties and the growth is slightly stronger than at the Rubira rootstock, so it is optimal for light and permeable sandy soils and is also suitable for poorer and stony soils, but they do not tolerate wet soils. The tolerance to the $CaCO_3$ content is up to 7%. It is also sensitive to frost damage in the root neck area. It is sensitive to viruses, but the quality of the fruit is also premium.

Suitable varieties

From the early varieties maturing at the beginning of July, resp. during the month of July are varieties Starcrest, Primerose, Royal Gold, Alexandra. Of the varieties ripening in late July - early August, Spring Lady and Royal Gem are suitable. Varieties ripening in August with attractive fruits are e.g. Dixired and Royal Glory. Similar to the Hungarian best variety for apricots, the medium-ripening Redhaven variety is the standard for peaches even today. It is also possible to grow Fairhaven or Halehaven varieties from the classic varieties. Of the varieties maturing at the end of August, e.g. Queen Lady, Platinum and Daisy. Varieties ripening in early September are e.g. Benedict, Cresthaven, or Symphonie. At the end of September, varieties such as Sensation, Royal Prince and Calred ripen. And for peaches, extremely late ripening varieties are e.g. Babygold 9, Laure and Gladys.

Of the nectarines, e.g. Early Devil, Snowqueen, Harblaze, Stark Redgold and sandwich nectarine Flateryna and others, although due to their stronger growth they are not suitable for all types of soils and medium-growing rootstocks.

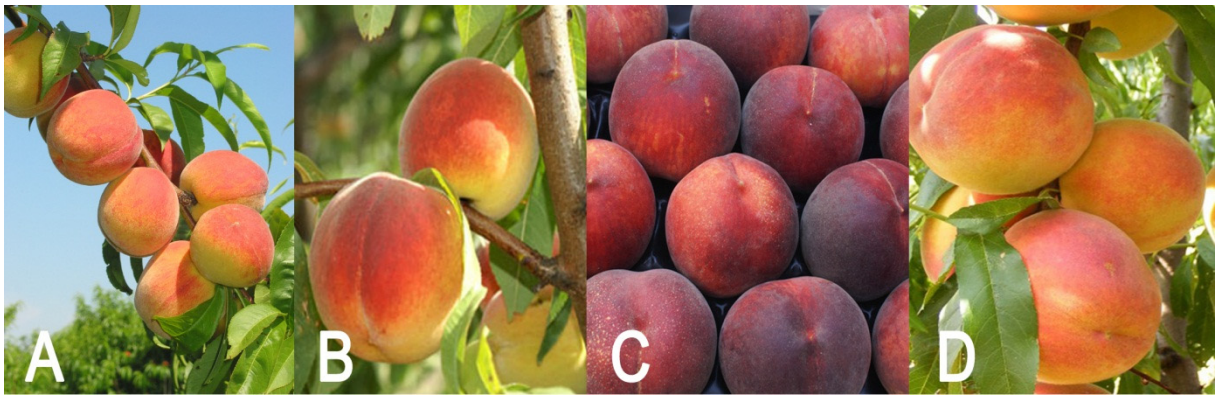


Fig. 33. A – Dixired, B – Redhaven, C – Vistarich, D – Cresthaven. (photo: Mezey)

Specifics of growth, pruning and training

Peaches are not a problematic species due to their growth, they naturally form dull angles of shoots from the parent branch. In addition, they are very willing to form full-fledged secondary shoots in the

second wave of growth and they are very suitable for a spindle forms. There is no need to bend or tie the shoots, because the shoots bend almost naturally to a position close to the horizontal.
When pruning, we pay particular attention to the so-called true native shoots (two flowering and one leaf bud), because only from these we get high quality fruits. The shoots only with flower buds are not suitable. It is possible to use a sectorial double pruning technique, while we perform the second stage in the summer, which also illuminates and aerates the crown.
We try to keep the crowns as bright as possible, for which we use complexes of summer pruning, which we can start with a length of 0.15 – 0.20 m, which is approximately in the third week in May. The cut of thicker branches, Zahn cut and cuts on the twisted stalk are made in the period of dormancy, resp. in the early spring.
There are several types of spindles for peaches; we will describe the most common. After planting, the central leader is shortened by a third and 3 – 4 suitable lateral shoots evenly spaced at an angle of 30° to the horizontal are selected. When the final height is reached, the central leader is cut or bent to a horizontal position. We treat the side branches with a sectorial double pruning, or they are bent and tied. A maximum of 3 side branches are established each year. The strongest are the lowest placed 3 maximum 4 branches, the branches in the higher parts of the crown are formed shorter to ensure the conical shape of the crown and actually have only the character of a native growth growing more or less horizontally or slightly obliquely. Bearing wood is formed partly on the central leader (in the upper part above the lower floor of thicker branches), but mainly on the lower branches. The side branches are cut minimally, the central leader is built by extending from the terminal bud. From the third year after planting, it is necessary to dilute the shoots, while removing, in particular, upright shoots. The side branches are shortened to the lower (outer) bud. Bearing wood is treated with a two-shoot system (one shoot treated with a longer cut at harvest and one with a shorter cut as a backup), in good conditions and in large-scale production, a long (American) cut is recommended. After the signs of aging of the side branches, we replace them with the system used for the spindle shape.
It is necessary to follow Zahn's rule. We usually remove coarser and out-beared branches at the age of 4 – 5 years with leaving a short stalk. In the place of the cut, regenerative shoots will emerge, which will become later (next year) bearing shoots due to the differentiation of flower buds and will bear fruit of selected quality.

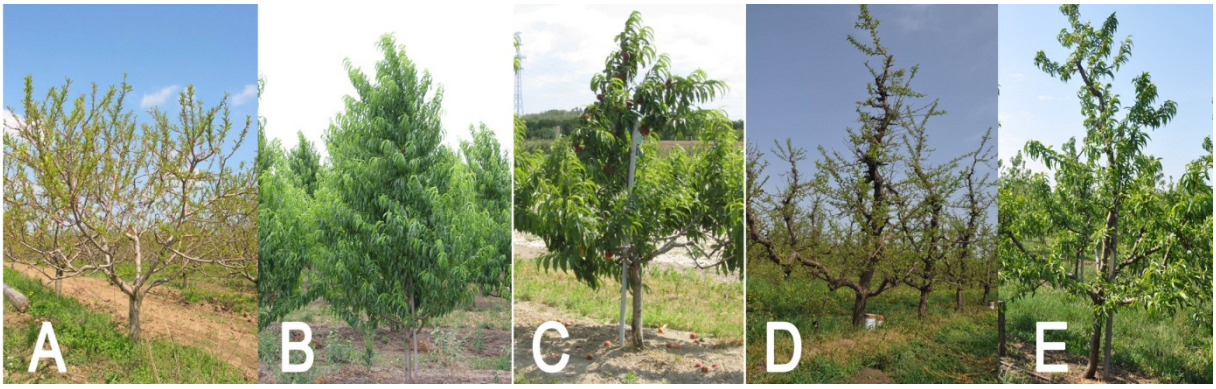


Fig. 34. Peaches - A – hollow crown, B – classical spindle, C – nectarine spindle, D – modern spindle (older tree), E – modern spindle (younger tree). (photo: Mezey)

Irrigation
As with all fruit species, peaches, especially on light, sandy soils, irrigation is needed, especially in the first years and during the pruning period. In the first year, we should irrigate at regular intervals, in smaller doses, during the dry season and in the summer months, every second or third day.
In the period of full fertility (from the 4th year after planting) it is necessary to irrigate before flowering, after flowering and during the formation of fruits. The period from the beginning of hardening of the stones to the end of fruit growth is also critical, as well as in dry localities even after fruit harvesting.

Cherries have long been a fruit species in which trees of lower height were a utopia. As in previous cases, a suitable week-growing rootstock was absent and cherries were grown either as rooted seedlings or inoculated on a strong-growing rootstock. The height of the trees almost always exceeded 5 m. The situation changed with the arrival of the weak-growing rootstock Pixy and Colt, who were replaced by weak-growing selections from Giesen, Germany, namely GiSelA selections. The GiSelA 3, GiSelA 5 and GiSelA 6 types have been successfully established in modern plantings across Europe.
Spindle cherries are slightly higher than other species, the volume of the crown is also higher. It is possible to grow spindles either in the classic height up to 2.4 m, but it is possible to grow them up to a height of 3.0 to 3.5 m. For the treatment of such trees, however, a ladder is needed, resp. plateau, but the yields are significantly higher.
The support system does not have to be used for cherry spindles, but in the case of a combination of weaker rootstocks, weaker growing varieties and light soils, we recommend using the same type of construction as for apple trees.
The advantage of spindles over conventional shapes is the better quality of the fruit achieved in the case of a slim spindle. As the fruiting branches on the trees are not old, the proportion of one-year-old wood is higher, and the fruit size is excellent. The conical shape of the tree and the young, thin bearing wood allow better penetration of light into the crown and thus to the fruits, resulting in better coloring and taste of the fruit. The application of pesticides to a smaller volume of crowns is more efficient and economical and reduces the pollution on the environment with chemicals.
It is possible to stretch a net over those type of trees and thus protect them from hail and damage from birds, it is also possible to apply a protective coating with foil to prevent fruit cracking due to rain.

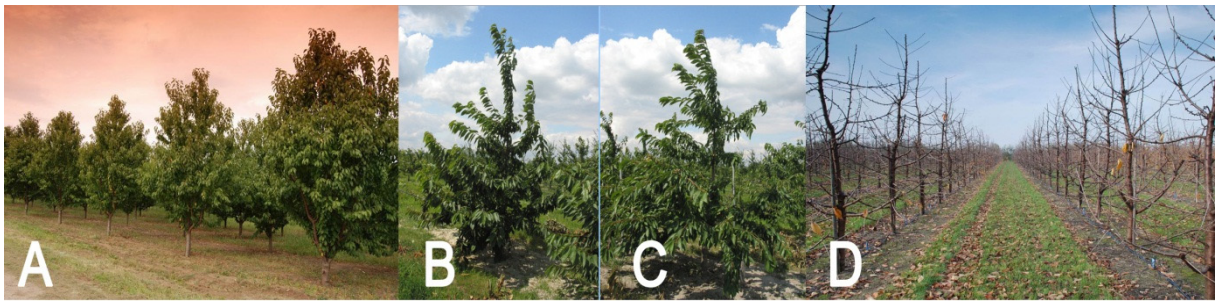


Fig. 35. A – sweet cherry dwarf-stem, B, C – young sweet cherry spindle, D – full-bearing cherry spindle (photo: Mezey)

Suitable growing locations
Although the root system of week-growing rootstocks is weaker than in the past, they require deeper, aerated, slightly moist soils with a slightly acidic response. They suffer from gummosis in heavy, cold and wet soils. Areas up to 200 – 400 m a.s.l. with an average annual air temperature of 8-10°C and an annual total precipitation of 600mm are required. Closed sites with late spring frosts are unsuitable.

Suitable rootstocks
The ideal rootstock for home gardens is the GiSelA 5 rootstock. Another advantage is the plasticity of the soil conditions, which means that it can be used in both heavier and lighter soils. An important feature is that it supports horizontal branching, i. the growing shoots and shoots have a appropriate growth angle from the central leader, the synthesis of auxins, which cause perpendicular growth, is suppressed and thus the differentiation of flower buds is promoted. Affinity with varieties is good; we record the lowest fallout in the orchard.
Rootstock is frost-resistant with good stability in the soil. A huge advantage is the higher specific bearing per unit area. In practice, this means that we harvest more fruit from a certain planting area

than from trees on another rootstock. This is related to the weak growth and the fact that we can plant more trees on the same area and at the same time the volume of crowns is also larger.
GiSelA 6 is also a suitable rootstock, which has a slightly stronger growth than Gisela 5 and therefore we recommend it especially for light soils. In heavier soils, the volume of the root system will be larger, growth will be strengthened, and the trees will be higher overall. In cases where you plan to grow spindles around a height of 3 m, this support can also be used for heavier and thicker soils. Due to its sensitivity to frost, we recommend it for southern areas.
For the highest quality soils and flawless agricultural technology, it is also possible to use the GiSelA 3 rootstock, which has weaker growth than the Gisela 5. The rootstock is suitable for "lazy" varieties on strong soils with sufficient moisture and roofing in intensive systems. We recommend it to the gardens only to a limited extent.
Rootstocks from breeding station in Holovousy are also relatively popular in central Europe region. P-HL-A causes a growth weakening of 40 – 70% with a specific relationship to varieties in relation to growth weakening. This means that it is not possible to say that growth is weakened by 70% for all varieties. Each variety grows differently on this rootstock. The positive is the acceleration of the ripening of the Kordia variety. In general, the specific bearing is higher, the disadvantage is poorer stability, in light soils it requires support. The P-HL-B undercarriage grows 10 – 15% stronger than the P-HL-A; it is suitable for higher spindle shapes or for light soils. It has good anchorage in the soil. The P-HL-C rootstock has 80% weaker growth than the seedling, the highest specific fertility among P-HL rootstocks and faster entry into bearing.
Of the other rootstocks that are more common in southern Europe, the Maxma Delbard, Tabel, Colt, SL 64 and Piku 1 rootstocks are suitable, but home nurseries do not prefer these rootstocks.

Fig. 36. A – foil covering prevents fruit cracking, B – fruit cracking by excessive water content. (photo: Mezey)

Suitable varieties
In the case of self-pollinating varieties, Lapins, Halka, Summit, or modern varieties Sweetheart and Celeste appear in gardens as suitable. However, it should be noted that although they are self-pollinating, we will achieve better and larger fruits if they are also pollinated with pollen from another variety.
In the case of self-incompatible varieties, it is necessary to be aware of the fact that it is not possible to combine any variety in planting. This applies to all self-incompatible varieties, not just cherries. However, cherries are specific to this and form the so-called incompatible groups, i.e varieties that cannot be combined in planting because pollination would not occur. The table lists suitable pollinators for the respective varieties.
Of the varieties widespread in commercial plantings, the Kordia variety is currently the most preferred, followed by the Regina, Karina, Těchlovan, or Van, Burlat and Celeste varieties.

Tab. 11. Pollination chart for sweet-cherries.

variety	Rita	Summertime	Burlat	Merchant	Giorgia	Sabrina	Celeste	Graze Star	Carmen	Samba	Summit	Satin	Canada Giant	Těchlovan	Sylvia	Van	Schneiderova	Big Star	Kordia	Lapinova	Karina	Regina	Sweetheart
Rita	X																						
Summertime		X																					
Burlat			X																				
Merchant				X																			
Giorgia					X																		
Sabrina																							
Celeste																							
Graze Star																							
Carmen									X														
Samba										X		X				X						X	
Summit											X		X										
Satin										X		X				X						X	
Canada Giant											X		X										
Těchlovan														X					X				
Sylvia																							
Van										X		X				X						X	
Schneiderova																	X						
Big Star																							
Kordia														X					X				
Lapinova																							
Karina																					X		
Regina										X		X				X						X	
Sweetheart																							

suitable pollination | no pollination | self-fertile varieties

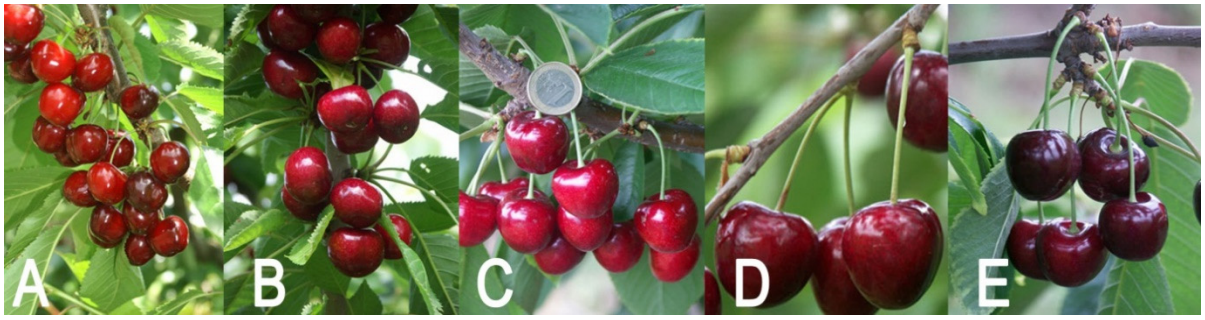


Fig. 37. A – Burlat, B – Celeste, C – Canada Giant, D – Kordia, E – Regina. (photo: Mezey)

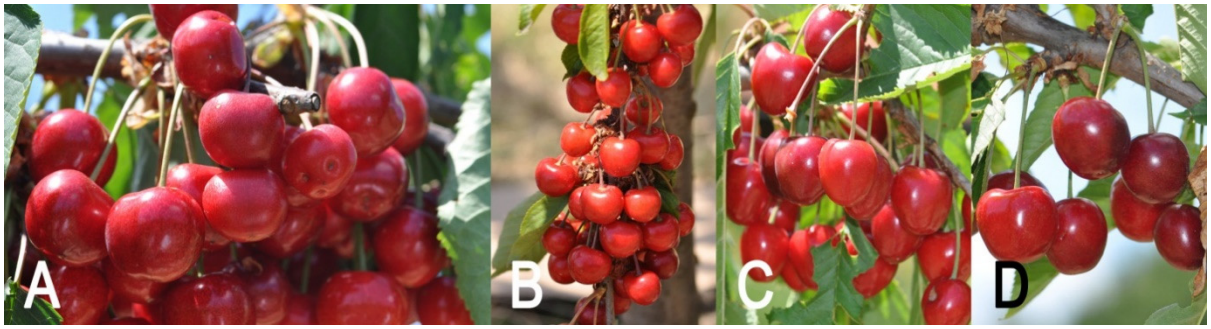


Fig. 38. Czech sweet cherry bredding. A – Justína, B – Tamara, C – Lívia, D – Fabiola. (photo: Mezey)

Specifics of growth, pruning and training

There are several types of spindles that have been tested for cherries. One of the most successful is the shaping system described by G.F. Zahn, that assumes planting material with a sufficient number of basal branches already established. Spindle-shaped tree formation using the Zahn method is feasible, but in later years after planting, the restoration of bearing wood in the lower parts of the crown may be unsuccessful due to the lack of permanent basal branches. It seems reasonable to combine Zahn's spindle with permanent basal branches, which is nothing but the well-known classic Dutch slender spindle with 4 – 5 permanent peninsular branches.

Due to the training of the slender spindle system, the basis of the tree structure is the permanent basal branches and the dominant central leader. The branches of the bearing wood are located on the basal branches and on the central leader. For cherries, it is extremely important to form branched basal branches, which balance the strong growth of central leader and acrotonic branching. In the case of this training system, the basal branches are bent at an angle of 80 to 90° from the central leader, in the first year using clothespins, then using a sectorial double pruning for one to two years. This approach to the pruning and training ensures good branch formation in the basal part of the crown. The central leader, starting from the second year, remains uncut. Strong shoots can form on it near the terminal bud, but they are pinched to 3 to 4 leaves at the end of June. Thin, horizontal shoots growing from the central leader are the basis of bearing branches in the following years if their top buds are not removed.

The suitability of the training procedure can be assessed according to the ratios of the thickness of the branches - the so-called Zahn's principle; the side branch should not have a diameter at the base greater than half the diameter of the parent branch from which it grows. If it is coarser, it indicates its too strong growth, which can be weakened either by bending towards a lower position (young branches), or by pruning the so-called weakened active suppository (Zahn´s cut), in which we shorten the main axis of the branch by cutting to a weaker branch growing on the underside of the branch (preferably with a position close to horizontal).

Restoration and removal of the out-beared branches growing from the central leader takes place after harvest, which is approximately four to five years old. We shorten such a branch, depending on the distance from the central leader, to 0.1 to 0.4 m. The higher the branch in the crown, the shorter the stalk will remain. If we did not remove the old wood, the basal areas on the branch would begin to heal and roughen unnecessarily. In addition, branches would be disproportionately elongated and would encroach on neighboring trees.

Growing cherries in the shape of a slender spindle is suitable in intensive very dense plantings of cherries with rows 4 m apart and a distance of trees in a row of 1.5 to 2.5 m, with a density of 1000 to 1500 trees per hectare. In gardens it is possible to grow with this system in a spacing 3.5x2.0.

Irrigation

Cherries are also a fruit species with high water requirements, especially in the first year after planting. In the period of fertility, we irrigate mainly about 10 – 14 days after flowering, when the fruits are intensively binding to the fruiting branch. The second critical period of irrigation is the period of intense fruit growth and hardening of the stones. Conversely, with too much moisture during or shortly before the harvest period, undesirable cracking of the fruit may occur.

PRODUCTION TECHNOLOGIES OF SOUR CHERRIES

Unlike all previous species, cherries are not found in large-scale production in major areas. Existing plantings date back to previous decades and are predominantly in the shape of dwarf-stems or quarter-stems. The spindle of sour-cherries does not occur in large-scale production. Nevertheless, the sour cherry is a fruit species which, unlike cherries, does not show apical dominance, the lateral shoots bend naturally and have a very suitable position to the central axis. The architecture of the crowns is very similar to that of cherries. We also use a type of spindle with an established basal floor consisting of 4 – 5 branches placed above each other and in space. Of course, we follow Zahn's rule and when the branch that grows from the central leader exceeds half the diameter of the central leader, it is necessary to either shorten it to a stalk about 0.2 m long, or remove the whole branch. The rest of the crown is based only on shoots and branches, which are fertile, so there should not be significantly thicker branches that would shade the lower parts. The problem with cherries is their features not create leaves or flowers on wood previously containing fruit last year, so it is very important to treat back to all the yielded two-year-old shoots.

Suitable growing locations

Cherries are less demanding on the soil conditions than cherries, they can also be grown on shallower soils, the pH can be even more acidic than cherries (5.5 – 6.5). However, they also do not tolerate cold and wet soils. Areas are up to 200 – 400 m. a.s.l. with an average annual air temperature of 8-10° C and an annual total precipitation of 600mm is preferred. Closed sites with late spring frosts are unsuitable.

Suitable rootstocks

As sour-cherries are very similar to sweet-cherries, the same types of rootstocks are suitable as for cherries.

Suitable varieties

As a result of the lack of interest of consumers and the fresh fruit market, there is also less incentive for breeders to market quality new varieties that would also be important from a European point of view, which is a great pity, however, because cherries are very neglected in terms of direct consumption.

The assortment is therefore still a late Morela standard, but we also recommend the varieties Morelenfeuer, Érdi Bötermö, Újfehértói Furtös, Morina, Gerema and Karneol.

Specifics of growth, pruning and training

The biggest problem with cherries is their feature not create leaves or flowers on wood previously containing fruit last year. We eliminate this defect by annually pruning the whole bare parts up to the parts containing leaves. If we do not do so, we get several meters of thin shoots without fruits and without leaves. Fortunately, the cherries also respond very well to the stronger dormant pruning of the three-four-year-old wood, where we will see new shoots with flowers and fruits in the future. Unlike cherries, they do not show such strong growth, but they react sensitively to deeper pruning, especially during vegetation. However, with a slender spindle, there should be no branches thicker than half the diameter of the central leader, so even some deep and strong pruning should not be considered.

Planting material, its cultivation and further care during the growing season is identical to that of cherries. The difference is in the total tree-height depending on the rootstock, where the overall character of cherry growth in combination with a weakening rootstock, e.g. GiSelA does not allow a total height of more than three meters. From the point of view of gardens, the optimal height of the spindles is 2.2 – 2.4 m.

Irrigation

Even with sour-cherries, it is very important to ensure sufficient water in young trees. Sour-cherries have a shallower root system compared to cherries, so regularity in water supply is essential for the optimal development of the young tree. During the bearing period, the critical periods of moisture demand are the same as for cherries.

Fig. 39. Advanced growing measurements. A – anti-hail nets (in picture is it without net), B – mobile system of rapid cooling (Karsu), C – pollinators. (photo: Mezey)

PRODUCTION TECHNOLOGIES OF BERRY FRUIT

CURRANTS

Suitable growing locations

Currants are especially demanding on the humus content of the soil. They are suitable for medium-heavy soils with a pH of 5.5 – 7.0. They generally thrive in higher growing positions, up to 600m a.s.l., black currants up to 300m a.s.l. The average annual air temperature should be around 6 – 8°C, for black currants 7 – 9°C, annual precipitation should be in the range of 500 – 700mm.

Suitable rootstocks

If we grow tree-shaped currants, we use golden currant (*Ribes aureum*) as a rootstock. We use ungrafted seedlings for the bush form.

Suitable varieties

Of the suitable red currant varieties, we especially recommend the Rovada variety with large berries and long tassels and the Junifer variety. Jonkheer van Teets, or Detvan and Tatran are still suitable varieties. Among the black currants are the varieties Titania and Triton and the older variety Ojebyn, the Polish varieties Tiben and Tisel, the Slovak varieties Eva, Otelo, Favorit and the Scottish varietis Ben Lomond, Ben Nevis and others. We recommend the Slovak varieties Primus and Blanka from white currants.

Suitable growing shapes

Currants can be grown in the shape of a bush, in a spacing 2.5 – 3x0.7 – 0x9m, or in the shape of a tree on the rootstock of a golden currant. Currants can also be grown in the shape of a wall, where the individual shoots are tied to a support in the form of a bamboo pin.

Specifics of growth, pruning and training

When growing shrubs, it is important that we ensure sufficient shoots from each age-category. In the case of blackcurrants, which also bear on annual wood, the oldest shoots are 3 years old, which we remove in the spring of the 4th year. We leave 12 – 16 shoots at the age of 1 – 3 years in each bush. In the case of white and red currants, which first bear on 2-year-old wood, the oldest shoots are 4-year-old, which we remove from the bush base in the spring of the 5th year after planting. We also leave 12 – 16 shoots aged from one to four years in such a bush. The pruning in following years consists from removing the oldest shoots.

Fig. 40. Modern spindle form of red currant, variety Rovada. (photo: Mezey)

Fig. 41. Yields of modern spindle forms of red currants can reach 13 – 20t/ha. (photo: Mezey)

Irrigation
The first dose is suitable just before flowering, the second dose during intensive fruit growth and we can apply one dose after harvest.

RASPBERRIES AND BLACKBERRIES

Suitable growing locations
They are especially demanding on the humus content of the soil. They are suitable for medium-heavy soils with a pH of 6.5 – 7.5. This fruit species can also be grown in colder and higher areas.

Suitable varieties
Among the varieties that deserve commercial attention are the once-bearing upright growing large-fruited varieties Tulameen and Schonemann, or Meeker. The remontant varieties are Autumn Bliss and Primeberry Sugana.

From blackberries, we recommend the Black Butte, Orkan and Loch Ness varieties, which are thornless, the Thornfree variety is already at its zenith and is tending to fruit rot. However, none of them tastes like the thorny variety Theodor Reimers.

Suitable growing shapes and pruning
They can be grown on open ground, or in containers, in semi-covered or covered areas. Raspberries can be grown by several systems.
Belt system for growing once bearing raspberries with wire-support. With this system, we leave 8 – 10 strong shoots per standard meter, which are attached to the support in the form of a wire on the line. Remove other shoots. The fruits are formed on two-year-old wood, which we remove after harvest and replace them with one-year-old shoots, which we tie again.
The wire rod should have a height of 1.2 to 1.6 m with one or two double wires at a height of 1.2 resp. 1.6 m and with two-wire wires 0.3 m apart. It is possible to use a wire of the = V = type, which allows better distribution of the shoots and their lighting.

An elegant solution for growing remotant varieties is to install a simple structure in the shape of a table of any length without a top plate, instead of which a mesh with larger meshes (10x10cm) is attached. The individual shoots of raspberries grow into this mesh and do not lie down, the growth is airy and precisely delimits as long as the raspberries "can" grow. This system is preferably suitable for remontant varieties. The pruning consists in pruning just above the ground after harvesting the fruit in the fall. The advantage of remontant varieties is that they bear on one-year-old shoots.

Fig. 42. Three-floor wire system and semi-covered area, variety Kweli with yields around 13t/ha. (photo: Mezey)

Blackberries are semi-bushes with a creeping growth character have less firm, long shoots requiring support. The wire system should be 1.8 m high, composed of individual wires with a height of 0.9, 1.2, 1.5 and 1.8 m, to which we tie growing fan-shaped shoots during the vegetation. Blackberries bear on biennial wood. After harvesting, we remove the harvested shoots. We recommend shortening new shoots before harvesting (on biennial wood), resp. remove the shoot terminal to support splitting. Spacing – 3.0 – 4.0m x 2.0 – 2.5 m, 6 to 8 strong annual shoots are left on adult plants.

Irrigation
The first dose of irrigation is suitable just before flowering, the second dose during intensive fruit growth and we can apply one dose after harvest.

GOOSEBERRIES

Suitable growing locations
They have similar habitat requirements as raspberries and blackberries.

Suitable varieties
Of the modern varieties, Hinomacki Rot with red fruits, Hinomacki Gelb with yellow fruits and Hinomacki Grun with green fruits are recommended. Of the red-fruited varieties, the Pax variety is also represented in the plantings, and of the green ones, the Mucurines variety.

Suitable growing shapes and pruning
Like currants, gooseberries can be grown in the form of a bush or a tree on the rootstock of a golden currant. In the form of a bush, we choose 2.0x1.0m spacing. Shrub should contain about 3 – 4 branches of various ages from one to 4 – 5 years. We remove the oldest out-beared branches from the base. We do not shorten the shoots.

Irrigation
The first dose of irrigation is suitable just before flowering, the second dose during intensive fruit growth and we can apply one dose after harvest.

STRAWBERRIES

Strawberries are currently very popular, both among consumers and producers. Strawberry self-picking is very popular.

Suitable growing locations
The habitat has similar requirements as raspberries and blackberries, with the soil pH having to be around 6.5.

Suitable cultivation systems
There are a large number of growing systems for strawberries, each with its own advantages and disadvantages. These are mostly belt planting systems.

The open ground belt system can be:
• without raised beds without foil
• without raised beds with foil
• on raised beds with foil

Belt system in semi-covered areas
• low, medium and high tunnels
• on open ground without raised beds without foil
• on open ground without raised beds with foil
• on lose ground on foil raised beds
• growing on raised stands

Belt system in covered areas
• without raised beds without foil
• without raised beds with foil
• on raised beds with foil

Depending on the number of plants and spacing, we distinguish:
• single-row belt system, where the plants are in one row in a spacing 0.35x1.2m and the number of plants 24,000 pcs/ha
• two-row belt system, the plants are in two parallel rows in a spacing 0.35x0.35x1.2m at a number of 48,000 pcs/ha
• two-row "checkerboard" belt system, the plants are in two rows and the seedlings are planted checkerboard in a 0.25x0.25x1.2m spacing at 66,000 pcs / ha

The planting material can be developed plants, which are planted on the site from mid to late August. They can be bare-rooted or in containers. A more used system is frigo-seedlings. These are classic seedlings that are stripped of leaves at the end of the vegetation and have a shortened root system. The result is a seedling without leaves, but with a left and undamaged heart and part of the root system. The date of planting can be different, in the case of field crops the date is usually from mid to late May, some producers plant in June. In indoor areas where year-round strawberries are grown on substrates, planting can be timed depending on the requirements of the harvest date – this is the biggest advantage of frigo-seedlings.

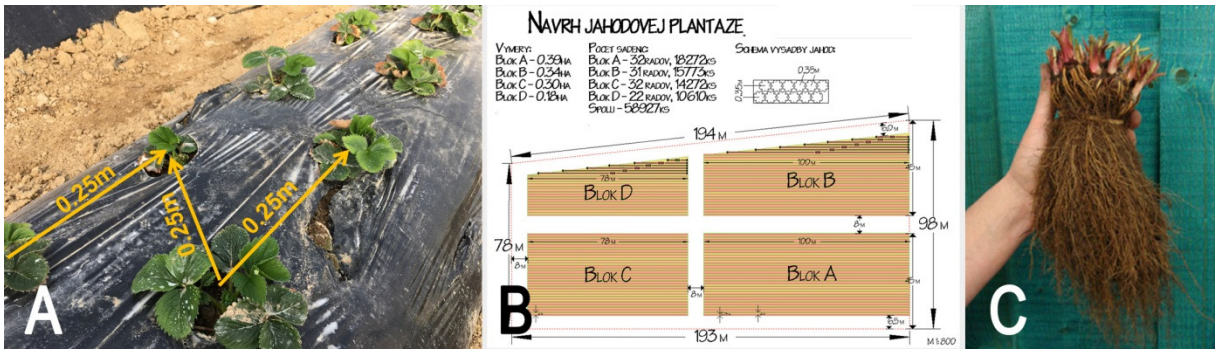


Fig. 43. With checkerboard double rows with a 0.25x0.25 m spacing, it is possible to plant up to 66,000 seedlings per ha, B – individual varieties should be planned in blocks, C – frigo seedlings are currently the most used planting material. (photo: Mezey)

Cultivation on raised beds has its advantages in several aspects. The first is to prevent the fruit from coming into contact with the soil, and thus there is a lower risk of the fruits being attacked by fungal diseases. As the fruits are not completely grounded, the risk of late spring frosts is partially reduced. The soil heats up more easily and quickly in the foil beds. The height and width of the beds can vary and depend on soil conditions; resp. used machinery for beds preparation. On too light and dry soils there is often a problem with the preparation of beds; it is not possible to ensure a sufficient height of the raised bed, which therefore does not fulfill its purpose. Disadvantages include the risk of freezing the soil on the beds.

Growing on the open field brings with it the risk of damage to the plantings and fruits by weather conditions. The vegetation is exposed to late spring frost, it partially helps to cover the whole planting with textiles. The vegetation is usually exposed to torrential rain and if the system is free of beds, the seedlings may not dry out early enough and can be attacked by various fungal diseases. In some years, there is a problem with sunburn.
The solution may be the use of low tunnels, which are installed in the width of the row to a height of about 0,3-0.5 m above the stand itself. In this way, the plants and fruits are not exposed to heavy rain or sunburn. Disadvantages include reduced penetration of pesticides and foliar fertilizers per stand, as well as limitations in handling during harvest or other technological treatment. In high tunnels, this problem is eliminated because the mechanisms move inside the tunnels. Disadvantages include higher acquisition costs as well as reduced crop rotation.

Fig. 44. A – strip planting in open field without raised beds and without foil, B – strip planting in open field and raised beds with foil, C – strip planting in foil tunnel on raised beds and with foil. (photo: Mezey)

The cultivation on substrates, which are placed directly on the ground, most often in the form of bags, which are punched in the appropriate spacing and the plants are planted directly into these bags, contributes to solving this problem. The disadvantage is lower efficiency and lower work comfort. Substrate culture on raised gutters allows for partial improvement. The disadvantage may be, due to

the investment, the length of the harvest period and thus a shorter market presence. These aspects are completely eliminated by the same indoor cultivation system, but with year-round heating. Seedlings can be placed directly in the bags with the substrate, they can be grown purely hydroponically, but they can also be placed in containers. There may be holes on the side of these gutters as well as the containers, from where we also obtain crops on the growing gutters. In the Korea system, two identical gutters are placed one above the other. The year-round heated areas enable the harvest practically all year round from frigo-seedlings, the planting date of which depends on the requirements for the quantity of the harvest.

Irrigation in field culture on open ground, but also in covered areas is solved in the form of drip, resp. spot irrigation. Water quality is important. Dosing usually takes place automatically and is controlled by a PC. Spot irrigation can be from above or from below. In almost every system, liquid fertilizer is also supplied to the irrigation water with organic or conventional fertilizer.

The equipment, especially in indoor areas, includes heating technology, heaters, frost protection systems and systems for maintaining the optimum temperature in the room. Additional lighting is required for reduced light intensity. It seems necessary to provide pollinators with the help of bumblebees, which are placed in special boxes designed for this purpose. Other aspects include moisture control, and in the case of low humidity, this is increased by fogging, but more often it is wetting the floor, it is not entirely advantageous if the plants themselves are wet. Other equipment includes carbon dioxide supplementation to the plants area. If necessary, a shading and heat shield is used to ensure that seedlings and fruits are not burned in the summer months.

Suitable varieties

Widespread varieties that are worth planting include e.g. Clery, Darselect, Elsanta, Rumba, Jive, Symphony and many more. Remontant varieties include Calypso, Everest, Evita, Aromas and others.

Irrigation

The first dose is suitable just before flowering. In the next, we water the strawberries regularly in the form of drip irrigation, if necessary, every 2 – 3 day. At the time of fruit formation, it is recommended to irrigate and add pre-calculated fertilizer doses to the irrigation every day.

PRODUCTION TECHNOLOGIES OF SHELL FRUIT

WALNUT

Suitable growing locations
Deep and nutritious soils with a neutral soil reaction and a low groundwater level are suitable. Warmer locations, sunny slopes up to an altitude of 300 m a.s.l. suit them. It is damaged by frost in closed areas.

Suitable rootstocks
Nuts can also be grown from seed, but in this case we will not see the harvest until 8-10 years, while the tree is massively large, takes up relatively much space and the fruits are mostly small with a hard shell. The nuts that are grafted have made weaker growth, which is advantageous in terms of treatment, space requirements and, importantly, the harvest usually appears for the third year after planting. Suitable rootstocks are black and gray walnut, but also other walnut selections.

Suitable varieties
For planting, we recommend large-fruited varieties with a thin shell (so-called paper mills, or semi-paper mills), such as Apollo, Seifersdorf, Mars, Lake, Jupiter. Rote Donaunuss (Geisenheim 1239) with a red core may be interesting. Hungarian varieties from the Alsószentiványi, Tisacsocsi or Milotai breeds are very good.

Suitable growing shapes and pruning
We recommend growing in the shape of a quarter or half stem. We will establish the first floor created from 3-4 branches, the next floors are established freely. The pruning consists of liberational pruning; we do it during the vegetation, after budding, or in August.

HAZELNUT

Suitable growing locations
The hazelnut is also suitable for higher growing areas with a permeable, sandy substrate, it has a relatively shallow root system distributed more in width, so they are not hindered even by a higher groundwater level. It is undemanding to the soil.

Suitable rootstocks
They can be grown as shrubs or grafted onto Turkish hazel (*Corylus colurna*) rootstocks, in which case they can be grown in the shape of a tree.

Suitable varieties
All varieties that occur in our country are suitable, ie Hall's giant, Lombard's white and Webb's. Of the varieties grown abroad, Buttler, Cosford, Ennis and Gunslebert are the most widely used.

Growing shapes and pruning
We grow it most often in the form of a bush with 10 – 12 basic shoots. It is possible to remove unnecessary shoots growing from the base of the bush; we do not shorten the shoots. From about the 10^{th} year, we are replacing the basic shoots with new shoots. Spacing 3.0 – 4.0 x 3.0 m, planting material – shrub with at least 3 shoots.

ALMONDS

Suitable growing locations
Almonds require a warm and sunny habitat, much like peaches. It also tolerates a higher $CaCO_3$ content in the soil, up to 12 – 15%, but has an increased sensitivity to frost and moniliosis.

Suitable rootstocks
Mostly selected almond seedlings are used.

Suitable varieties
Vama, Zora, Hana varieties are available from Slovak varieties. Nonpareil, California and Mission are the most widely grown varieties abroad.

Growing shapes and pruning
After planting, they have rapid growth and development. The formation of shoots takes place in several growth waves at a young age. Pruning during vegetation is recommended. The most commonly cultivated shape is a quarter-stem, or a half-stem with a central leader with 4 to 6 skeletal branches on a faint floor spirally spaced along the leader. It is also possible to choose a hollow shape in which the procedure is similar to that of a hollow peach crown, but less pinching is required. Spacing: 5 x 5 to 8 x 8 m. Planting material: 2-year old tree with established crown.

SWEET CHESTNUT (Castanea sativa)

Suitable growing locations
It requires soils with a weakly acidic reaction, well supplied with nutrients. To ensure more thorough pollination, it is recommended to plant more varieties; it can be grown not only in warm areas, but also in protected habitats in higher altitudes. It requires lighter to medium soils and well aerated. They are characterized by very good frost resistance. The best areas are with warm summers and cold winters. Planting is 10 – 12 m apart. They overcome summer droughts very well.

Suitable varieties
Chestnuts of Slovak origin are e.g. Bojar, Mistral, Mojmír, from foreign e.g. Bouche de Betizac, Boche Rouge, Doree de Lyon, Marigoule, Marlene (self-pollinating).

Growing shapes and pruning
High stem with a free-growing crown, pruning only to establish skeletal branches in the 1st to 2nd year after planting. Sometimes it is possible to make a pruning to liberate the crown, when we remove dead, cross-growing and overgrown branches on an adult tree.
Fertility: by generative seedlings, the trees start to bear around 15 years, grafted around 10 years. It blooms in late May and the flowers do not freeze, so the bearing is annual.

PRODUCTION TECHNOLOGIES FOR OF LESS KNOWN FRUIT SPECIES

QUINCE (Cydonia oblonga)

Suitable growing locations

It requires a warm, sheltered habitat, like apricots or peaches. It is quite demanding on growing conditions. It is best suited to heating soils well supplied with nutrients. It does not tolerate soils with a high calcium content, where it suffers from chlorosis. It is less demanding on the moisture, its precipitation of 550 – 600 mm is enough, but with additional irrigation it significantly increases fertility.

Suitable rootstocks

For tree shapes we choose clones of quince, pear seedlings or hawthorn.

Suitable varieties

All varieties that occur in our country are suitable, i. e.g. Champion, Bereckého, Leskovačska, Vranja, Mammut.

Growing shapes and pruning

Dwarf-stem or quarter-stem with a free-growing crown with 4 skeletal branches on the floor. It is also possible to grow them in the form of a shrub.

Fig. 45. Commercial quince planting in a form of quarter-stem (photo: Mezey)

BLUEBERRY (*Vaccinium corymbosum*)

Suitable growing locations

The most important factor in growing blueberries is the pH of the soil. Blueberries are most suitable for pH 3.2 – 4.2. At this value, the plants grow optimally and achieve regular harvests. We therefore choose light soils with a high proportion of organic content, which naturally creates an acidic environment. For soils with a higher pH, we recommend filling a pre-dug pit or part of the soil profile, which we mill (1.0x0.5m) with a mixture of upland peat, forest rake, sawdust and bark, and plant the plants in this base. Another measure is to adjust the pH of the soil in its entire profile. We reduce the soil reaction by adding elemental sulfur and over several years depending on the buffering ability. As these measures are financially and time consuming, in our conditions, a possible solution is to grow the bushes in large containers, which we can but do not have to sink into the ground. We grow them on open ground, but we recommend growing in foil tunnels, resp. under the nets.

Suitable varieties
There are currently a number of varieties on the market, the choice is great. We recommend sorting them according to maturation. Varieties ripening in mid-July include Sunrise, Bluetta, Duke. Patriot, Northland, Nelson, Elliot, Chandler mature in late July. Bluecrop, Blue Ray, Blue Gold, Darrow ripen in early August. In mid-August, e.g. Berkeley.

Growing shapes and pruning
Blueberry has a basitonic character of growth, fruits are usually in the terminal part of the shoots, depending on the variety on old wood or the basic shoots growing from the base of the plant, the most valuable is vital 2 to 3 year old wood. We grow them in a spacing 3.0 – 3.5 x 1.0 – 1.5m. A properly cultivated shape is a shrub with 10 to 20 branches, gradually built, with an annual renewal of 1/4 to 1/5 of the number of branches by selecting suitable basic shoots after reaching the desired number of branches. Support system is usually not necessary.

Fig. 46. A – belts planting system of bushes, nets are as a protetion against birds B – additional irrigation and annually mulching is necessary, C – growing blueberries in containers. (foto: Mezey)

BLACK CHOKEBERRY (*Aronia melanocarpa*)

Suitable growing locations
It can be successfully grown from lowlands to higher mountain areas. It requires sunny places, but it can also withstand partial shade. It grows reliably in all types of soils, it can grow even in heavy, clayey soils with lower humus content, only plant growth and fruit quality are poor. Medium-heavy, slightly acidic soils with sufficient humus are more suitable for regularly high fruit production. Higher, wetter locations in Slovakia are the most suitable. Due to the later flowering, the second half of May, does not suffer from late spring frosts and yields regularly.

Suitable rootstocks
If we plan to grow chokeberry like a tree, we graft it on the seedling of a European mountain ash (*Sorbus aucuparia*) at the required height.

Suitable varieties
All available varieties on the market are suitable, e. G. Nero, Galicjanka, Viking.

Growing shapes and pruning
The most common is cultivation in the form of bush. Fertility is ensured by mixed buds located in the top and side positions on the annual wood and branches.
We plant seedlings in a spacing 3.0 – 4.0 x 2.0 m. The shrub consists of 8 – 10 branches reaching a height of approximately 1.5 – 2.0 m. After planting, the shoots are deeply shortened (to 4 to 5 buds). The following year, the elongating shoots are shortened slightly to balance and the number of branches

is increased to 8 to 10. Excess shoots growing from the base of the shrub and thickening shoots growing on the branches forming the skeleton of the aboveground part are removed; a detailed pruning is usually not necessary, only when necessary removal of damaged branches. After the onset of signs of aging, it is necessary to rejuvenate by pruning to convert to stronger shoots growing from the base of the plant and re-growing the branches.

BLACK ELDER (Sambucus nigra)

Suitable growing locations

It is especially suitable for southern to southwestern expositions, where it blooms profusely and provides a large harvest of fruits. It is a light-loving plant; it also thrives in partial shade. It grows on fresh, humus-rich, and loose aluminous, sandy-aluminous or even clayey, nutrient-rich and especially nitrogen-rich soils. Tolerates light but also heavier soils, but reasonably moist and loose. It is characterized by considerable resistance to winter frosts and there is no danger of damage even by spring frosts, as it blooms (depending on the area) in May to July.

Suitable varieties

The most cultivated in region of central Europe are Sambo, Haschberg and Donau.

Growing shapes and pruning

It has a basitonic growth character with a tendency to form a small tree, the ability to grow in the shape of a tree with native root system. Fertility is ensured by one-year-old shoots growing from older wood and in the field, to achieve higher fruit quality and regular harvest, fertility is focused on strong shoots growing from a deep pruning every year from older wood. A suitable spacing is 6.0 x 4.0 – 4.5 m. The tree forms a quarter-stem with 10 – 15 basic branches, which are regularly renewed. Every year, during the spring pruning, the harvested two-year-old branches are removed and replaced by strong shoots growing from the base of the crown, while the number of left shoots gradually increases to 10 to 15.

Fig. 47. Black elder variety Sambo forms a low and compact shapes. Flovers and fruits are harvested. (photo: Mezey)

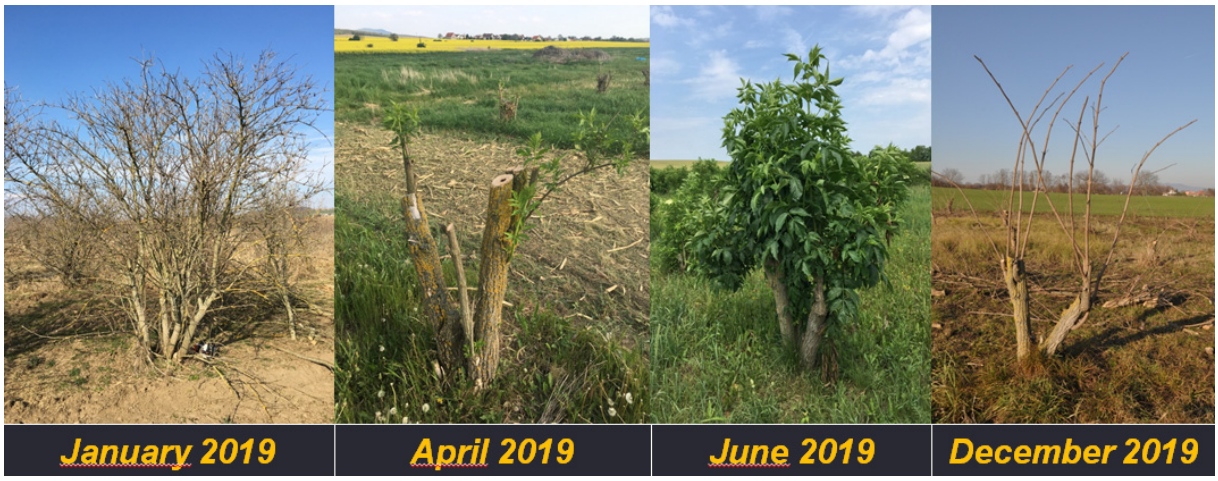


Fig. 48. Rejuvenation of an old elderberry bush in one year. (photo: Mezey)

COMMON SEA BUCKTHORN (*Hippophae rhamnoides*)

Suitable growing locations

The peripheral areas of cultivation also suit them; it is not demanding on nutrition, we grow it without chemical spraying. Sea buckthorn is self-sterile, so male plants are in dire need of pollinators. The ratio of male to female plants is 1: 8. It also grows very well in areas with heavy air pollution. It tolerates dryness and low temperatures well. Fertility is high and regular. It hardly suffers from diseases or pests at all.

Suitable varieties

Practically all varieties that are commercially available can be planted, such as e.g. Askola, Hergo, Leikora, Vitaminnaja, Polmix (male), Slovan, Dorana, Slunéčko.

Fig. 49. Some of commercially cultivated varieties. (photo: Mezey)

Growing shapes and pruning

It forms a shrub with 10 to 12 skeletal branches. After planting, the shoots are shortened by one to two thirds and weak branches are removed, as well as branches with flower buds. In the following years, 2 to 3 basic shoots are selected each year during the spring pruning, which should be slightly shortened to support growth. In the first 2 years after planting, parts with flower buds are removed so as not to slow down the growth and building of the shrub. As part of the annual pruning, all horizontal branches and weakly branched wood, on which lower-quality fruits are usually formed, are also removed. After reaching the desired number of branches, the 2 to 3 oldest branches are always

removed from the base during the spring and replaced with the same number of strong base annual shoots. In years with too many flower buds, it is recommended to regulate fertility by diluting native wood.

Fig. 50. A – belt cultivation systems of shrubs, B – buckthorn in full bearing period, C – yield is mostly on 2-year old wood, D – we collect whole branches with fruits by pruning, which are deep-frozen E – and subsequently knock-off with the help of sticks. (photo: Mezey)

EDIBLE HONEYSUCKLE (Lonicera kamtschatica)

Suitable growing locations

They are one of the least demanding types of fruit in our country for growing conditions. It grows well both in the lowlands and at higher altitudes. Due to its low demands on warm and short growing season, it is very suitable for medium and higher mountain areas of Slovakia. We can also plant it in frost basins, as it is extremely frost-resistant, it can withstand frosts of up to -45 ° C in wood, and -7 °C in flowers without damage. Less fertile soils with a weakly to moderately acidic reaction are optimal. Sandy, sandy loam and loamy soils with sufficient humus are suitable.

Suitable varieties

Among suitable varieties belongs Altai, Amur, Aurora, Borealis, Sinoglaska, Vostorg, Wojtek, Zojka and many others.

Growing shapes and pruning

It is self-sterile, so an important prerequisite for its reliable fertility is the selection of at least two suitable varieties. For planting, we will use pre-grown plant material at least one year old, supplied with a well-rooted root system. The optimal spacing for most varieties is 2.5 x 1 m. After being removed from the container or from the soil in the nursery, we plant the seedlings in a permanent habitat 3 – 4 cm deeper. We do not prune or shorten after planting the shoots. Due to the fact that the honeysuckle begins to vegetate in early spring, the optimal planting date is autumn. However, the plants in the containers can be planted all year round, except in the winter, when the soil is frozen. It is grown in the form of a bush. In the following years, before the onset of vegetation, we shorten the young shoots to achieve a solid base of the bush. In adult period, we focus on pruning old, sick and damaged branches and branches that excessively thicken the shrubs. It is not demanding for irrigation and fertilization, but at the time of fruit growth it reacts very well by increasing the yield. The second fertilization is carried out in the summer to support the growth and maturation of young shoots.

Fig. 51. Modern, intensive planting of honeysuckle and basal part detail. (photo: Mezey)

COMMON MEDLAR (*Mespilus germanica*)

Suitable growing locations
Not demanding on soil and climate conditions. It tolerates heavier, moist and cold soils, grows very well in partial shade but also in direct sunlight and can withstand strong winds. It is self-pollinating and does not suffer from fungal diseases and almost no pests. It grows best and bears on lighter calcareous soils.

Suitable rootstocks
It is grown rather than a shrub, but if we plan to grow a medlar as a tree, we plant it on our own seedling, hawthorn, quince, or pear at the required height.

Suitable varieties
They are many suitable, e. G. Metz, Boom en Vrucht, Bredase Reus, Macrocarpa, Nottingham Neu, Royal, Westerveld, Dunkelsteiner Wald, Eschenauer Halbkugel, Puch-Weingarten, Rossatz, Schönbrunner Riesenmispel, St. Michael Kirche.

Growing shapes and pruning
A dwarf- or quarter-stem with a free-growing crown with 4 skeletal branches on the floor. It is not demanding on pruning and training. In the pre-spring period, you only need to make a slight educational incision, during which you remove drying or frozen branches and lighten the crown. Older specimens need to be rejuvenated, similar to apple trees, to increase fertility.

Fig. 52. Shrub, flower and fruits of medlar. (photo: Mezey)

APPLE ROSE (Rosa pomifera)

In addition to the aforementioned apple rose to large-fruited types of roses that can be used, we can include the following:

- *Rosa villosa* L., syn. *R. pomifera* - Apple rose
- *Rosa cinnamomea* L. – Cinnamon rose
- *Rosa moyesii* Hemsl. Et Wils. – Moyes' rose
- *Rosa pendulina* L. – hanging rose
- *Rosa pruhoniciana* – Pruhonice rose
- *Rosa roopae* Lonacz. – Roop's rose
- *Rosa rugosa* Thunb. – wrinkled rose
- *Rosa sweginzowii* – Sweginz's rose
- Fruit rose Joja – hybrid variety *R. rugosa x* Karpatia

Suitable growing locations

It is relatively undemanding to cultivation; it has no special requirements for the soil in which it is grown. We can successfully grow it in almost all climatic areas of Slovakia, because it is sufficiently frost-resistant. It thrives best in loamy, sufficiently moist soils, in a sunny location. From a fruit-growing point of view, the variety is valuable because it has one of the highest vitamin C content of all mild climate zone fruit species. It contains up to 1250 mg / 100 g. Due to their size, the fruits are easy to harvest and process.

Suitable varieties

The Slovak variety of the Karpatia is the most commercially cultivated apple rose in our region.

Growing shapes and pruning

A suitable spacing is 4x3m. The growing shape is a shrub with 6 to 8 skeletal branches, regularly renewed. It requires more intensive pruning only in the first years. After the fourth or fifth year, we start removing older than four-year-old wood, because the best fruits are on two- to three-year-old wood. We also remove all dried branches from the bushes.

Fig. 53. A – Apple rose forms compact rounded bushes with the height about 2m.. B – pale-rose flowers opens in spring, C – fruit set on well-pruned bushes use to be high. D – Fruits ripens in the autumn. (variety Karpatia). (photo: Mezey)

SERVICE TREE (Sorbus domestica)

The fruit can be divided according to its shape into:
- *var. maliformis* – apple-shaped
- *var. micropyriformis* – small-pear
- *var. obtusipyriformis* – obtuse pear
- *var. pyriformis* – pear-shaped

Suitable growing locations

In culture, it is grown mainly in the hills on the sunny southern and southwestern slopes. It is a light-loving and thermophilic tree that grows well in a nutrient-rich habitat, not too wet or wet. On the contrary, it is able to withstand stony soils, dry, their reaction is neutral to alkaline (it prefers more calcareous soils). Although it is able to withstand air temperatures down to -30°C and is less sensitive to late frost than oak, it prefers a warm and temperate climate with an extended growing season. It is light-sensitive and tolerates shadow only in the first years. Despite his good ability to grow, he is a weak competitor.

Service-tree tolerates direct sunlight and short-term water deficit in the soil. It is therefore suitable for afforestation of dry and warm habitats (including unstocked areas). It prefers soils with favorable physical properties, sorption-saturated with an acidic to neutral soil reaction.

It does not like deep plowing around its stem, which is signaled by the drying of entire branches within the crown or excessive grazing of cattle. On the contrary, it is suitable for permanent grassland in the range of min. one and a half width of the crowns. Roots are characterized by strength, very well anchored.

Suitable rootstocks

We graft or bud on rootstocks from own seedlings, or on seedlings of mountain-ash (*Sorbus aucuparia*) or pear seedlings.

Growing shapes and pruning

As a solitaire, it is a high-stem with a free-growing crown. Prune only to establish skeletal branches in the 1st to 2nd year after planting. In orchards, it is possible to keep its more compact shapes by pruning and training.

Growth is greatly affected by the environment where this tree grows. If it is like a solitaire in fields or gardens, its growth is smaller, but the crown is large, widely distributed. It is higher in the forest (it is maintained at the level of the surrounding vegetation), but the crown is smaller and bears less fruit. Of the fruit and forest trees, it is one of the most resistant to smog and air pollutants, so it can be used in industrial centers.

Fig. 54. A – extremly compant bush planting, B – Apple-shaped type, C – pear-shaped fruit. (photo: Mezey)

MOUNTIN ASH „MORAVICA“ (Sorbus aucuparia subsp. Moravica)

Suitable growing locations
Demands and use are the same as chokeberry; it is also suitable for higher areas. Deep and moist soils are ideal for growing, but it can also adapt to less favorable growing conditions. It is also suitable for growing in mountain areas.

Suitable rootstocks
If we plan to grow as a tree, we plant it on the rootstock of mountain ash at the required stem height.

Suitable varieties
The varieties Granatina, Likernaja, Alaja Krupnaja, Krasnaja Krupnaja, Nevežinskaja, Konzentra, Rosina are suitable for large-scale cultivation as well as growing in gardens.
Crossbreeds with other species, e. G. chokeberry, or medlar

Growing shapes and pruning
Most often in the form of a quarter-stem, or bush with a free-growing crown in a spacing, depending on the shape of 3-5x1-3m.

WHITE MULBERRY, BLACK MULBERRY (Morus nigra, Morus alba)

Suitable growing locations
Ecologically, it is a light-loving and thermophilic species growing on various soils, including sands, on which it is even used as an anti-erosion tree (e.g. in windbreaks), as it tolerates summer droughts well in areas below 400-500 mm of annual rainfall. This is finally reflected in its most frequent cultivation on Žitný ostrov and Východoslovenská nížina. It thrives best on deep, loamy, loamy-sandy, well-aerated and especially lime-rich soils. It does not tolerate wet and waterlogged soils and is sufficiently frost-resistant.

Suitable rootstocks
We grow them on their own seedlings.

Suitable varieties
Botanical species (black, white, red) and varieties derived from them such as Trnavská, Globosa, Pendula are mainly grown.

Growing shapes and pruning

Half-stem with a free-growing crown with a central leader and 3 to 4 branches on the floor, with a looser shape on the second floor. After planting in the spring, after budding, we strongly shorten the plant to a strong vegetative bud. There is no need to worry about shortening, a bigger mistake will be made if the tree is shortened less (or not at all) than more. It should be noted that planting itself will damage more than ¾ the roots, which changes the ratio between the above and below ground of the tree. In the first year, we will grow only a strong central leader, which is the basis of the stem and the future crown. We pinch the young branches right after the first leave. In the second year, we will grow a thin crown consisting of 3 – 4 skeletal branches. These are a good basis for future growth.

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