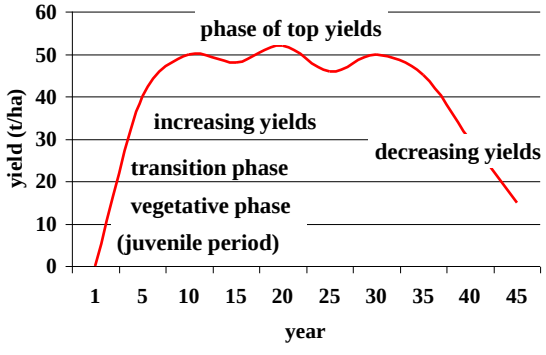
Physiological bases of temperate zone fruit production

Main periods of the life cycle of a fruit plantation

- (**Juvenile period** – not present in the case of grafted trees; its length depends on the genotype)
- **Vegetative phase** – a period after planting (grafting) during which the plants do not flower; trees should be kept in the vegetative phase when their structural frameworks are being developed
- **Transition phase** – when few flowers are being formed
- **Increasing yields** – trees begin bearing fruits, yearly income becomes bigger than yearly productions costs
- **Top yields** – extent of vegetative and generative organs of the trees should be balanced
- **Decreasing yields** – a period of decreasing vegetative growth, thus less yield, quality is also inferior

Main periods of the life cycle of a fruit plantation



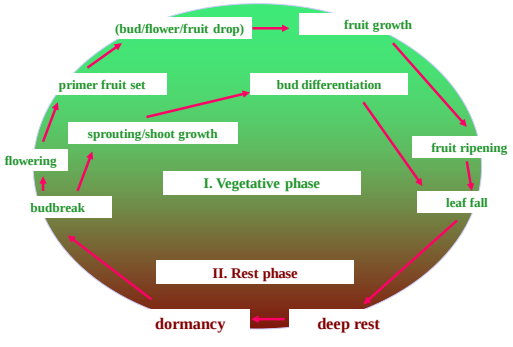
Length of life span of a plantation depends on

- the species
- the intensity of the cultivation
- the training system
- the environmental factors
- the economical and market factors

Maximum age of fruit plantation for getting subsidisation connected to fruit production in Hungary

- 2 years – strawberry
- 10 years – currents, gooseberry, raspberry, blackberry
- 15 years – elderberry, sea buckthorn
- 20 years – pome fruits, stone fruits, almond, hazelnut
- 50 years – chestnut, walnut

Phenological stages of fruit crops (yearly cycle)



Rest and dormancy phase 1.

- **Rest: an internal condition that renders the apical meristem incapable of growing despite favourable conditions**
- **Dormancy: a quiescent condition of shoot apices imposed by external conditions that are unfavourable for growth**
- **For the whole plant this period lasts from leaf fall until bud break**
- **For buds it starts earlier than for other parts of the plant**
- **Onset of rest: when buds undergo a gradual transition in the fall from a dormant stage into rest**

Rest and dormancy phase 2.

- **Apices require time for endogenous changes to occur so that they can pass from the resting phase to the dormant phase**
- **Rest period: duration of exposure to cold required for resumption of normal shoot growth**
- **Chilling requirement: the amount of cold needed to satisfy the rest; varies by species and also by cultivar**
- **For pome and stone fruit buds 6°-7°C seems to be optimal temperatures for satisfying the chilling requirement; temperatures below freezing are apparently ineffective**

Duration below 7°C needed to satisfy rest requirements of some deciduous fruit trees

Species	Hours	Days
Almond	200-350	8-14
Apricot	700-1000	29-41
Apple	1200-1500	50-62
Cherries, sweet	1100-1300	46-54
Cherries, sour	1200	50
Kiwifruit	450-700	19-29
Peach and nectarine	1000-1200	42-50
Pear	1200-1500	50-62
Persimmon	<100	
Plums, European	700-1100	29-46
Walnuts, Persian	500-1500	21-62

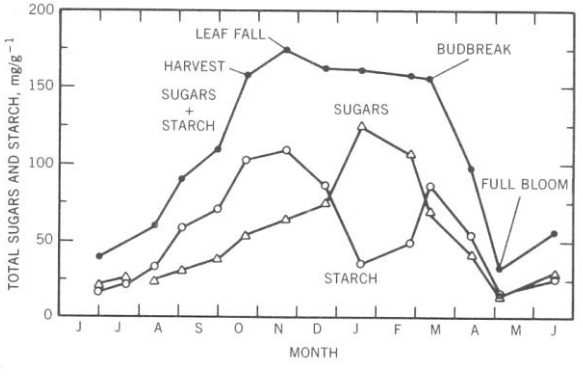
/Ryugo, 1988/

Rest and dormancy phase 3.

- **Chilling lowers respiration rate, enhance amylase activity → starch hydrolysis →more soluble carbohydrates**
- **Accumulation of an auxin precursor during the winter led to the breaking of rest period**
- **After rest is satisfied, any elevation of temperature should hasten budbreak**
- **When trees do not receive sufficient chilling, flower buds may abscise, and leaf buds will emerge slowly**

Shoot growth

- **A preformed shoot is developed before budbreak**
- **Budbreak usually needs 8-10°C**
- **The bud elongates into a shoot**
- **Shoot grows in length because of cell division in the apical meristem followed by cell division in the subapical region**
- **First shoot growth rate is slow, then it accelerates, and later in the season slows down again; terminate and indeterminate growth**
- **Initial flush of growth utilizes reserve carbohydrates, nitrogenous compounds and minerals**
- **Starch level reaches its lowest level at budbreak, it rises to the summer maximum as shoot growth slows down**
- **Grand period of growth: early summer, when shoots elongates and leaves expand the most rapidly**



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Root growth

- Root growth is slow during the depth of winter but accelerates in late winter, two to six weeks before budbreak, provided the soil temperature is above 4°C
- Alternation in seasonal periodicity of root growth is not observed in young, vigorous, nonbearing trees
- In bearing trees root growth slows when shoot growth accelerates
- Root extension depends on
  - edaphic conditions
  - cultural practices: pruning, fruit thinning
  - inherent growth characteristic of the species

Flower bud differentiation

- Floral initiation – the differentiation of floral primordia
- a vegetative bud is biochemically stimulated and changed to a reproductive bud
- usually happens within 6-8-(16) weeks after anthesis
- antagonistic effect of fruits, promotive influence of leaves
- cultural treatments which reduce tree size promotes formation of flower buds, while invigorating treatments delay flower formation
- lowering light intensity deters flower bud differentiation

- Causes for flower bud drop:
  - extreme summer heat, over 40°C
  - competition among developing organs
  - winter injury, under -21°C
  - lack of winter chilling

Flower development

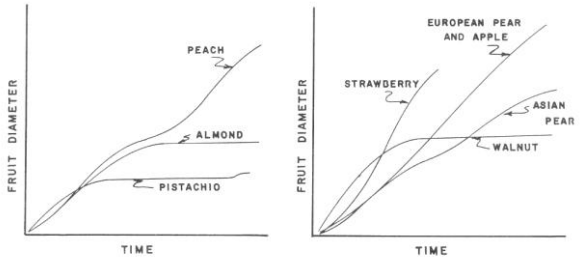
- Floral organization – the differentiation of the individual flower parts; from that point progression of flowering is irreversible
- Floral maturation – growth of floral parts, differentiation of the sporogenous tissues, meiosis, pollen and embryo sac development
- Anthesis (flowering)

Pollination

- Flowers that are not pollinated usually wither and abscise, except for parthenocarpic cultivars
- Double fertilisation → zygote and endosperm are formed
- Factors influencing pollination:
  - floral morphology and insect visitation
  - pollen sterility
  - abnormal embryo sac development
  - dichogamy (the period of stigma receptivity does not coincide with that of pollen shedding)
  - environmental conditions (lack of winter chilling, wind, extreme temperatures)
  - cultural practices (moderating tree vigor, adjusting pollinizers, mechanical and hand pollination)

Fruit development

- Three waves of abscission (bud/flower/fruitlet):
  - late winter – because of lack of chilling requirement
  - after full bloom - unpollinated flowers
  - ten days later – lack of proper double fertilization
- Fruitlets which did not drop will begin to develop
- Cell division phase
  - a few days for berry fruits, 2-4 weeks for stone fruits, up to 8 weeks for pomes
  - less fruitlets on the tree → longer cell division period
- Tissue differentiation
  - individual cells differentiate within each tissue and acquire their mature morphological characteristics
- Cell enlargement
  - vacuole becomes bigger, cell wall becomes thinner, additional substances are synthesized



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Factors effecting fruit growth

❑**Endogenous factors**
- **Number of cells per fruit**
- **Leaf:fruit ratio**
- **Reserve food supply**
- **Time of ripening of the crop**
- **Seed formation and distribution**

❑**Environmental factors**
- **Temperature (degree days, excessively hot temperature)**
- **Water stress (size →← taste ?)**
- **Winds**
- **Light**

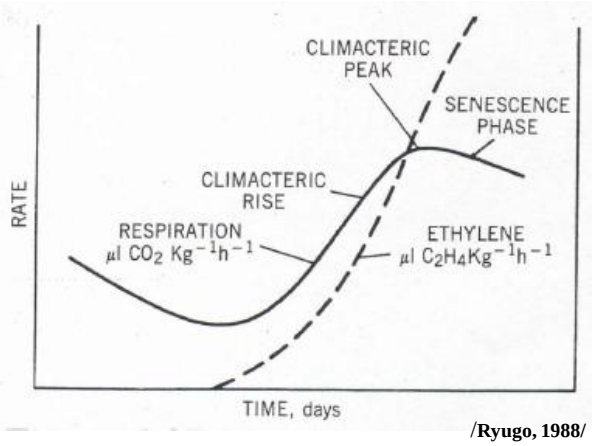
❑**Fruit thinning**

Ripening

- **Mature fruit: a fruit that has reached such a stage of development on the plant that it will ripen following harvest**
- **Ripe fruit: a fruit that is ready to be eaten**
- **Ripe fruits can not be stored very long**

Processes during ripening

- **Soluble solid content (Brix°) increases**
- **Starch content decreases, sugar content increases**
- **Acidity decreases**
- **Flavour and aromatic compounds are synthetized**
- **Firm and crisp texture changes to tender and juicy**
- **Chlorophylls are degraded**
- **Pigment formation – coloration; carotenes, xanthophylls, anthocyanins**
- **Respiration rate decreases, but later increases (climacteric rise and climacteric peak), (then decreases again); climacteric and non-climacteric fruits**
- **Ethylene is synthetized**



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