Viticulture

Grapevine growth & canopy management

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1. Annual grapevine growth cycle

*The **annual growth cycle** of grapevines refers to all biological processes that take place in the vineyard during 1 year, from bud break in spring to leaf fall in autumn, followed by winter dormancy. Regarding winemaking, each growth phase is vital for the quality of the wine that will produced.

Physiological & anatomical changes

- The **vegetative season** alternates with **winter dormancy**
- It occurs in **3 stages**
  - **Stage 1**: **bud break** (late March-early April) to flowering (mid-May-early June)
  - **Stage 2**: **flowering** until **veraison** (early August)
  - **Stage 3**: **veraison** until **maturity** (September)

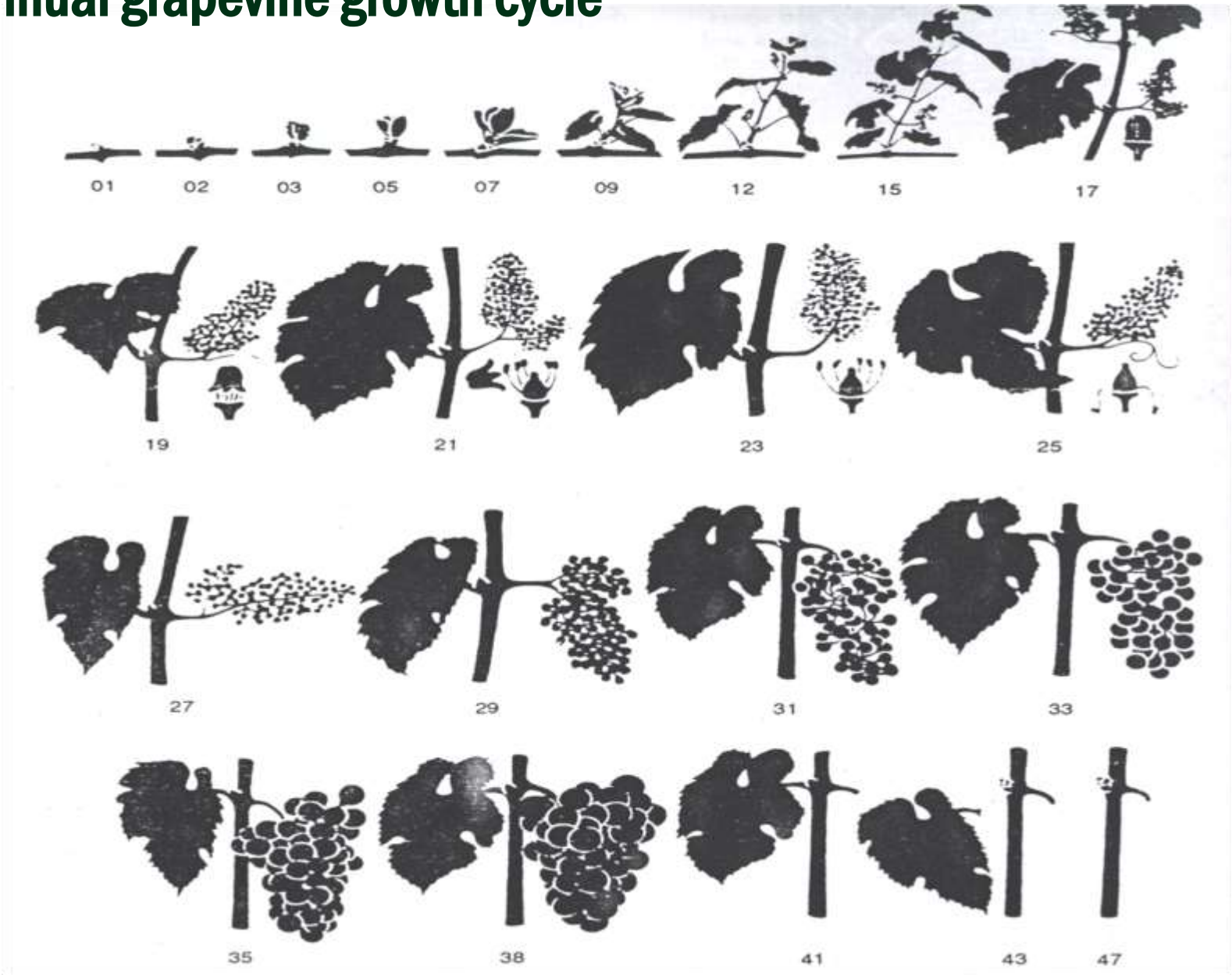
1. Annual grapevine growth cycle

Physiological & anatomical changes

- ✓ **Tropical areas:**
  - ✓ **Temperatures** >12°C, average 20-36°C
  - ✓ **Rain** >1000 mm
  - ✓ **Winter dormancy** happens
  - ✓ Theoretically **3 productions** per year / **1** is **commercially suitable** (growth cycle 110-130 days)
- ✓ **Cuba**:
  - ✓ **2 commercially suitable productions** / year
- ✓ **South India**:
  - ✓ **2 productions** (July, February)
  - ✓ **2 prunings**

Viticulture – growth & canopy management

1. Annual grapevine growth cycle



2. Winter dormancy

The phase after the fall of the leaves - the **buds** enter into "lethargy" (**inability to grow**). The following phases can be distinguished:

1. **phase "before entering dormancy"**
   normal bud development in spring under suitable conditions (**~8 days, 20°C**)

2. **"lethargy entering" phase**
   reduction of bud development time even under suitable conditions (**~50 days, 20°C**)

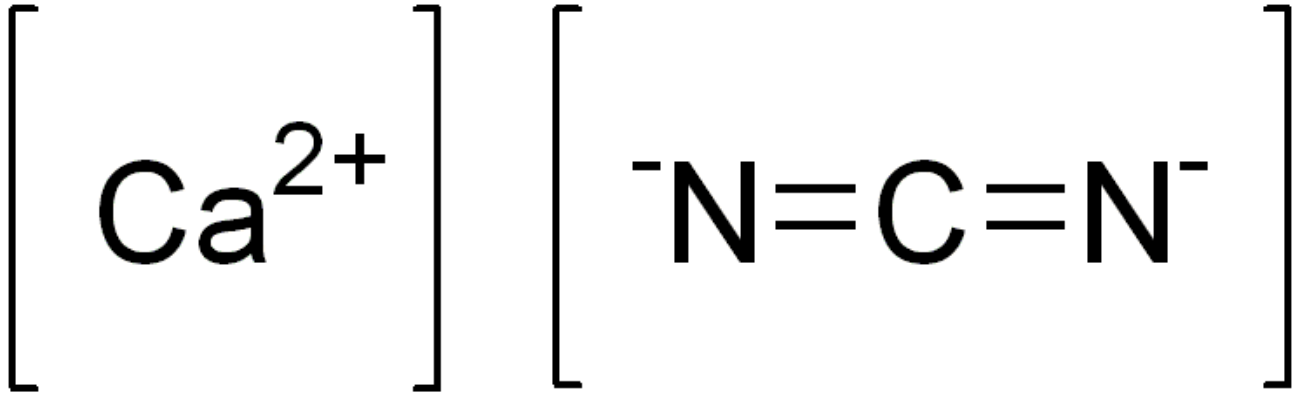
3. **"lethargy" phase**
   Complete loss of bud growth (**from mid July**) – it is associated with the accumulation of inhibitors (e.g. **abscisic acid**)

4. **"lethargy lifting" phase**
   the buds must remain for a continuous period at low temperatures (**7-15 days, 8-13°C**) to pass into this phase

5. **phase "after the lifting of lethargy"**
   ability of buds to break and grow organs under favorable conditions (**early spring, T> 10°C**)

2. Winter dormancy

Bud growth is accelerated by administration of **calcium cyanamide (2-4%)** in February after pruning

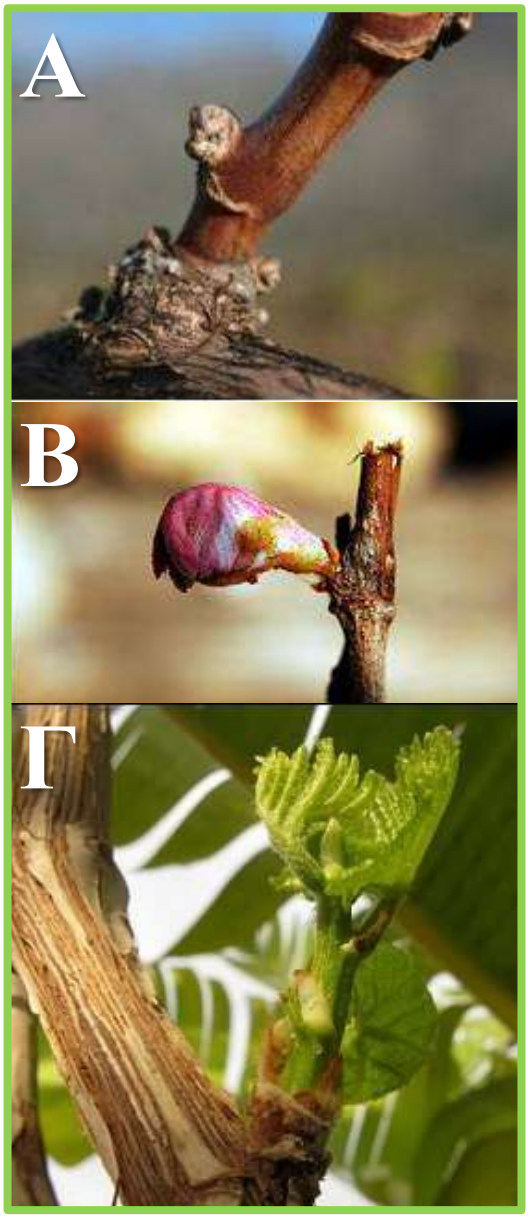


3. Grapevine bleeding

https://www.goodfruit.com/soil-moisture-critical-at-bud-break/

- Bleeding is the first visible manifestation of the plant's transition from winter dormancy to the sprouting period
- Fluid leakage from the pruning incisions is observed, which means that the root system is activated due to increase of soil temperature and adsorption of water by the roots
- It stops shortly before the buds sprout

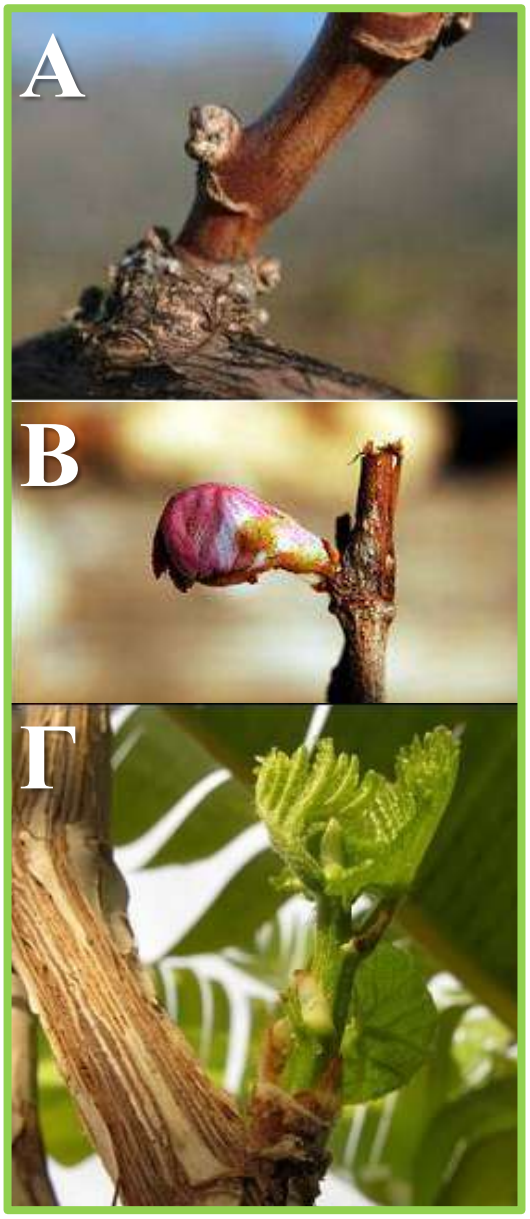
4. Bud breaking



- It is the swelling and "opening" of the buds
- Germination date is considered when **50%** of the buds are in stage (B) and depends on the vine variety:
- **Early sprouting varieties**
- **Medium sprouting varieties**
- **Late sprouting varieties**

* *in areas with common spring frosts the cultivation of early sprouting varieties should be avoided*

4. Bud breaking



Sprouting is affected by:

- **Temperature**
  (favoured at >10°C)
- **Geographical latitude**
- **Pruning period**
  (delays when pruning is delayed)
- **The nature of the soil**
- **The humidity**
- **The vine shoot vigour**
  (delays in thick shoots)

5. Shoot development

- From sprouting to leaf fall, vegetation progresses in successive stages (according to *Baggiolini & Baillod*)
- The increase is due to the activity of the **apical meristem**
- The **internode spaces** reach their final length in a period of **12-32 days**
- The increase follows the general characteristics of a sigmoidal curve

5. Shoot development

- Growth is controlled by the **hormonal balance** of the shoots
- It is accelerated by by **auxins / gibberellins**
- It slows down by **inhibitors** such as **abscisic acid**
- During **flowering** the shoot length increases **(>5 cm/day)** & during the **summer period** it decreases **(<2 mm/day)** due to accumulation of inhibitors from the leaves (that are at the stage of aging), water stress, high temperatures, nitrogen deficiency etc.

5. Shoot development

- The growth rate is optimal at **25-30°C** and decreases completely below **11°C** and above **38°C** for most varieties
- Growth stops completely in summer with the drying of the **shoot tip** and continues in autumn with the **lateral shoots**
- The growth rate of new foliage is important for the infestation of foliage diseases (e.g. downy mildew)
- Thus the new vegetation must be protected by spraying (copper or fungicides)

5. Shoot development

Vine shoot vigour

(the relative growth rate of the shoot)

- It is estimated by the weight of the shoots cut during the winter pruning
- e.g. in a warm area vineyard with regular irrigation, the pruning wood is **~600 kg/acre** (3 times more than a less favorable vineyard)

5. Shoot development

Shoot maturation

- During the evolution of the vegetative period, **anatomical/morphological** changes occur that lead to maturation of the shoot:
  - ✓ **Color change** (from the shoot base) from green to dark brown
  - ✓ **Increased elasticity**
  - ✓ **Formation of new wood vessels**
  - ✓ **Cork formation**
  - ✓ **Exfoliating of bark** (peeling)
  - ✓ **Starch accumulation** (and other substances) in the cells

5. Shoot development

Shoot maturation

- Maturation is important for the vine's resistance to low temperatures and for adequate starch reserves for the new vegetation (until the new foliage acquires a satisfactory photosynthetic surface)
- Maturity is assessed **macroscopically** by:

✓ Control of the **hardness** of the shoots or **xylem/pith ratio** (when the pith is **>60%** the shoot is considered immature and unsuitable for asexual propagation of the vine)

✓ By **iodine/starch test** (appearance of violet hue in the presence of starch, or yellowish when starch levels are low)

✓ By **analysis of carbohydrates** (starch, sugars)

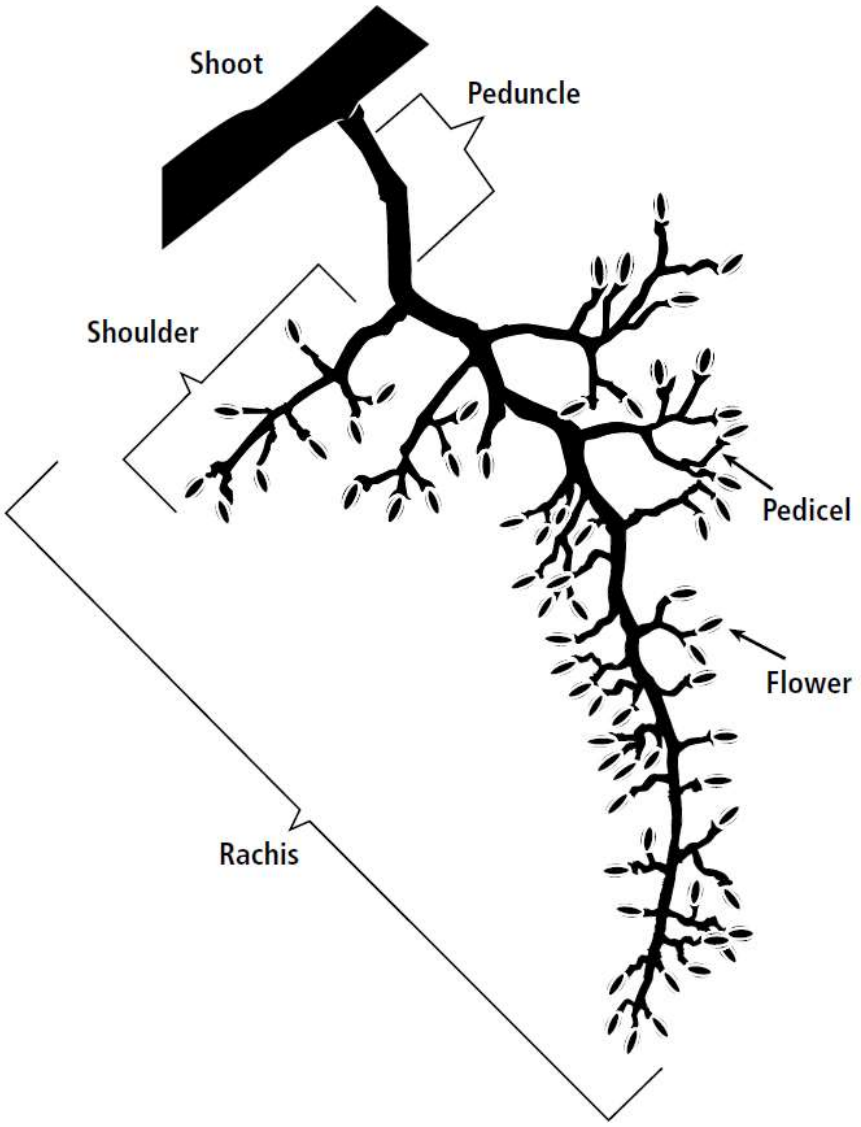
6. Flowering

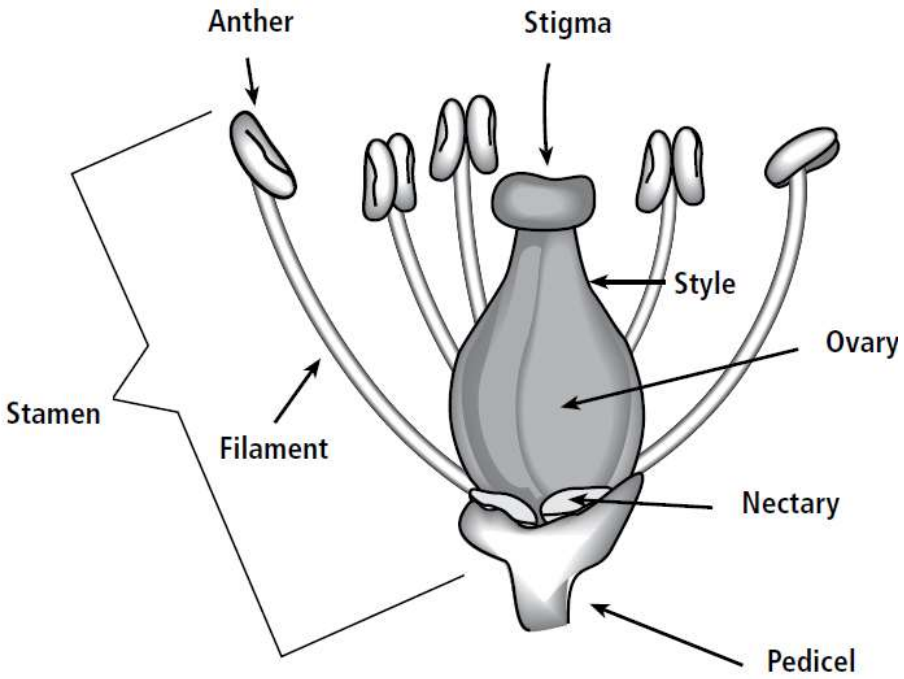
- **Inflorescences** (flower clusters) appear with the shoot growth, and in mid-May blossom begins
- Not all inflorescences grow normally, and a part dries and falls (mainly in weak or young plants)
- In some inflorescences a fall of flowers is also observed, and they are **reversed** into **tendrils** ("***filage***")
- Flowering is completed in **5-10 days**
- Temperature **15-35°C** (optimal **20-25°C**)
- The flowers may be fertilized by their own pollen but mainly by that of the surrounding flowers

Photo by A. Bekatorou, 2022
Vine in the Archeological site of Vounteni Patras, Greece

https://en.wikipedia.org/wiki/File:Grape_-_inflorescence.jpg

6. Flowering





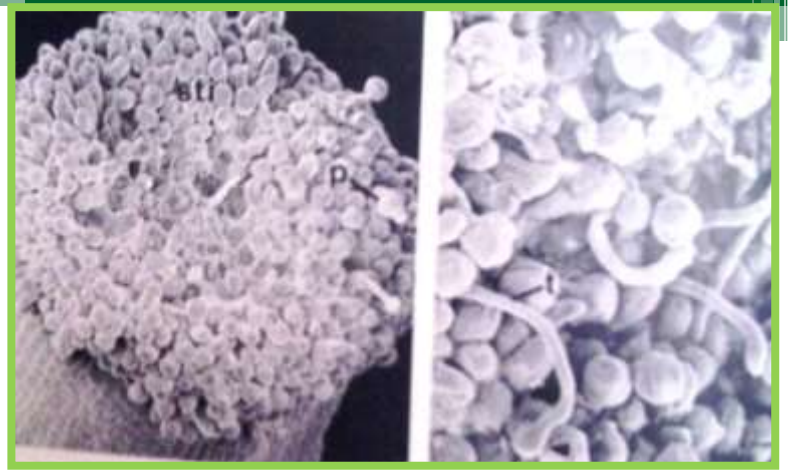
Grape Berry Growth and Development
Nick K . Dokoozlian; https://iv.ucdavis.edu/files/24467.pdf

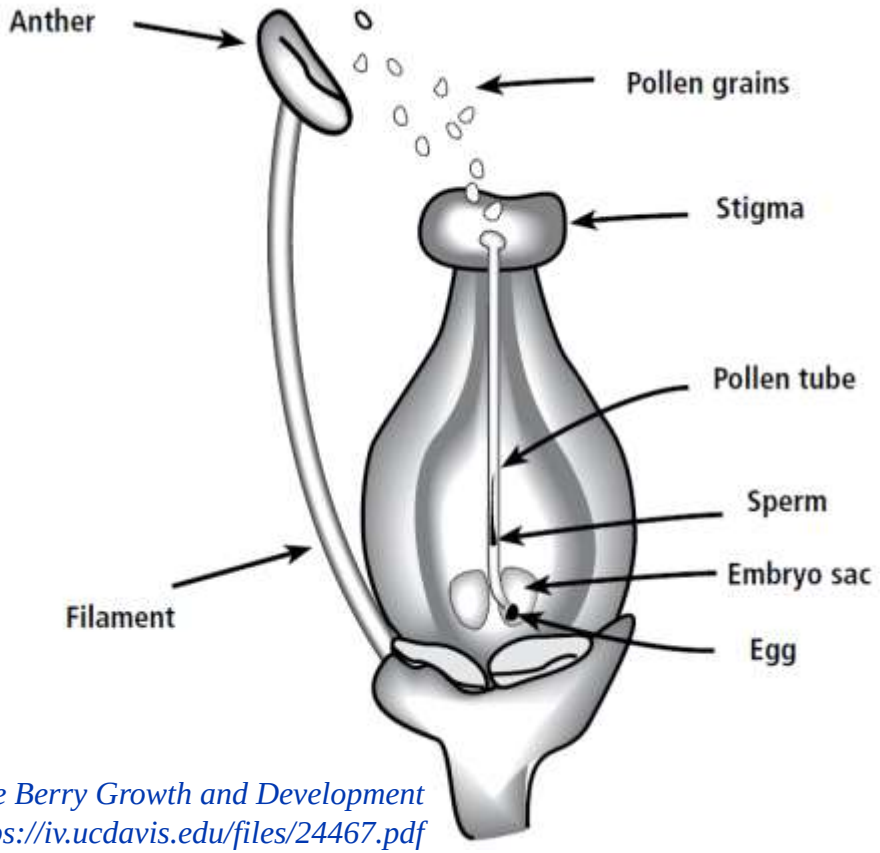
6. Flowering

Fertilization

- Release of pollen from the **anthers** of the **stamen** and transport by air or insects

- When the pollen grains come in contact with the **stigma** of the **pistil**, they absorb water, and germinate (creating a pollen tube that reaches down to the **ovary** and enters an **ovule**, where a sperm unites with an egg to form an embryo, which develops into fruit)





Grape Berry Growth and Development
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6. Flowering

Fertilization

- Pollen fertility is affected by the presence of **Boron** - Boron deficiency leads to reduced fertility and extensive **flower drop (*"coulure"*)**
- The presence of a large percentage of small and seedless grape berries is called "***millerandage***"

Treatment of millerandage & couloure

- Apply practices such as **tip pruning** (summer pruning) so that the shoots do not compete with the flowers for nutrients uptake
- Interventions with various **chemicals** (**growth inhibitors, polyamines**)

6. Flowering

Parthenocarpy

- **Absence of active embryos,** e.g. as in the case of the Corinthian currants - Parthenocarpy is the process of producing fruit without the fertilization of any seeds, which renders them **seedless**.
- The ovary is fertilized directly with pollen, divides and transforms into fruit
- Seedless grapes are grown from **cuttings** (amputated parts of a vine carrying the genetic defect that causes it to grow seedless grapes).

7. Determination of maturation stage

Maturity *(ripeness)* is the state of an organism, or of an autonomous part of an organism, when its development has been completed (growth and differentiation) as a whole. **In the case of grapes for wine production we distinguish**:

(a) **Biological or physiological maturity (BM):** When the seeds have completed their development and can germinate when found at suitable conditions.

(b) ***Commercial or industrial or technological maturity (CM)***: When the grapes acquire the required **sugar content** and **acidity** required for a specific quality of wine. For dry wines from early maturing varieties, the CM is before the BM. In cold areas maximization of sugar concentration occurs when the acidity is still high.

Commercial Maturity Index (CMI):

CMI = Sugars (g/l) / Tartaric acid (g/l)

8. An approximate diary

December	Year 1	(e.g. 2022)	Plant ordering
Summer	Year 2	(2023)	Soil preparation
March	Year 3	(2024)	Planting
Spring	Year 4	(2025)	Grapevine pruning
September	Year 5	(2026)	First harvest

9. Types of grape vine cultivation

A. Conventional cultivation

- It considers the soil as a simple substrate and the vine as a means of grape production
- It treats the vine as a plant that receives water and minerals from the soil and creates organic compounds through photosynthesis
- It uses technical and scientific knowledge for more intensive production
- It considers as hostile any plant or animal life form that impedes maximum grape yield, and treats it with the use of pesticides or herbicides

9. Types of grape vine cultivation

B. Good agricultural practice

- In contrast to the conventional cultivation, it aims to avoid or minimize synthetic pesticides and preparations (proper quantities at the right time)

- Its aim is to reduce the negative environmental impact without affecting the economic benefit

9. Types of grape vine cultivation

C. Organic cultivation

- It does not use any synthetic fertilizers or chemicals
- It considers the soil, plants, and animals as an integrated system
- Vineyard fertilization is done with composts and soil treatment is minimal
- The other plants are not considered competitors and the protection is done only with **sulfur** and **copper sulfate** without affecting the normal balance and reducing the production capacity

10. Canopy management

What is the grape vine canopy?

- The **aboveground part of the grape vine** (trunk, cordon, stems, leaves, flowers, and fruit). It includes all the annual germinating and reproductive parts of the plant. It is distinguished in:

  ✓ **Outer – Inner layers of leaves**

  ✓ **Open** (non -shaded) & **Dense** (shaded) – A dense canopy includes a large ratio of inner layers of leaves

10. Canopy management

What is the grape vine canopy management?

- It is a set of techniques by which we achieve changes **in position and number of the shoots and fruits** in space and time
- It **aims** to optimize the **microclimate** conditions within the canopy and achieve a **balance** between vegetative growth and fruit growth

Canopy management techniques:

- ***Winter prunings***
- ***Green prunings***

10. Canopy management

Optimization of the microclimate conditions in the canopy

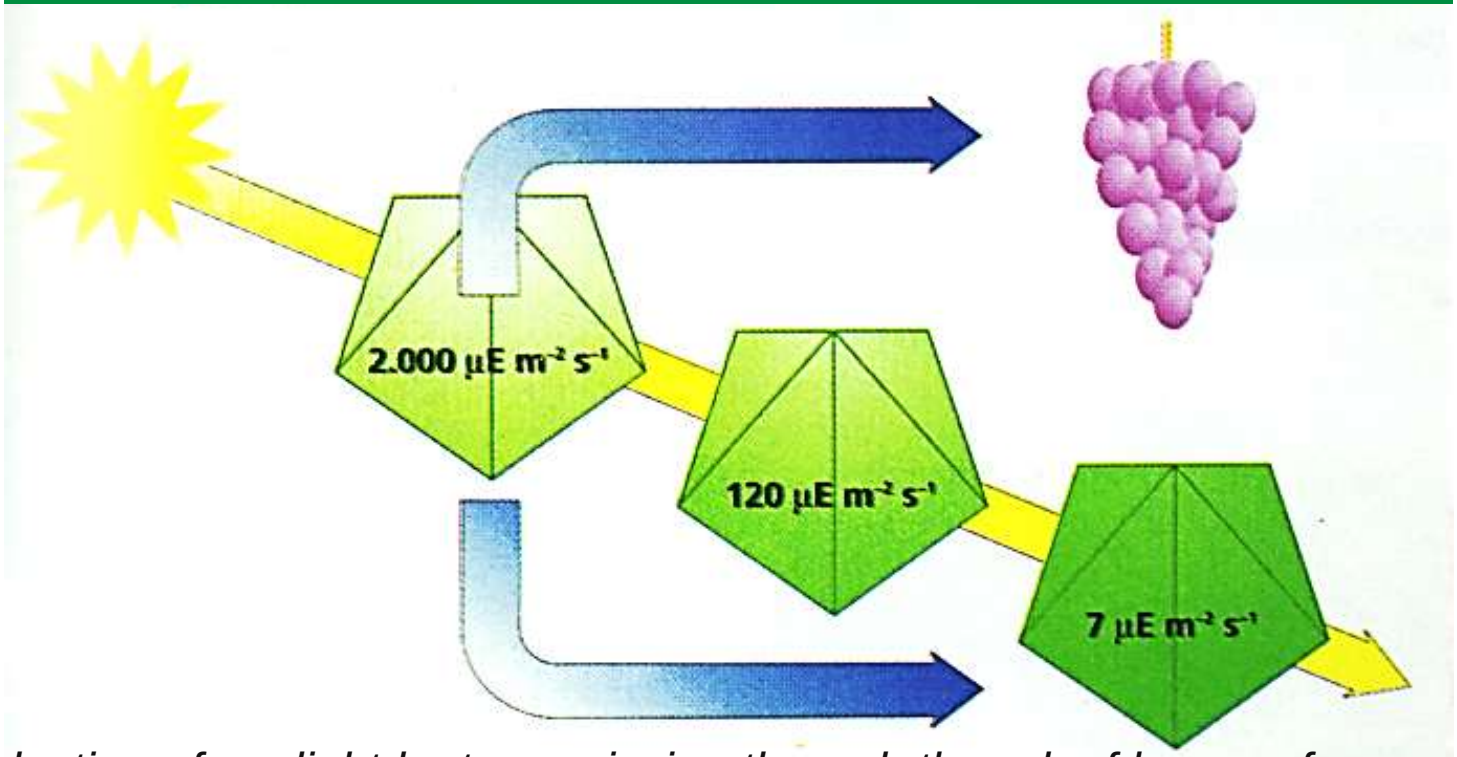
Creation of excellent climatic parameters inside and in the immediate environment of the canopy in order to:

- Maximize solar energy intake and photosynthesis rates
- Minimize water losses due to evaporation
- To ensure the health of vegetative organs (leaves and grapes) against infestations especially by fungi
- To ensure good transfer of sugars from the leaves to the grapes

10. Canopy management

Optimization of the microclimate conditions in the canopy

Limitation of light penetration through the foliage



Reduction of sunlight by transmission through three leaf layers of a canopy. The average photosynthetically active light transmission per leaf is only 6%

10. Canopy management

Optimization of the microclimate conditions in the canopy

Cabernet Franc canopy on Ruakura Twin Two Tier trellis. Note a blue board is positioned behind the canopy, emphasizing the leaf and fruit exposure, and canopy gaps. Rukuhia, New Zealand. (Photo R.S.)

Cabernet Franc canopy on vertical shoot-positioned trellis. Note limited fruit exposure and yellow leaves due to shading. (Photo R.S.)

10. Canopy management

Pruning: **Partial or total removal of vine parts**

Purpose of pruning:

- The control of the number of sprouting buds
- To con troll the grape load control / foliage
- To optimize the microclimatic conditions in the vine canopy

10. Canopy management

Basic principles of pruning

- The robustness of the canopy depends on the photosynthetic activity of the leaves during the period of shoot growth
- So pruning weakens the canopy
- The vigour of the shoots is inversely proportional to their number
- The number of fruit clusters is inversely proportional to the shoot vigour
- The fruit carrying shoots come from canes from biennial wood

10. Canopy management

Prunings

Winter prunings:

- Removal of wooded shoots and canes

Green prunings (canopy management):

- Spatial arrangement of the annual vegetation and selection of the desired load of grapes

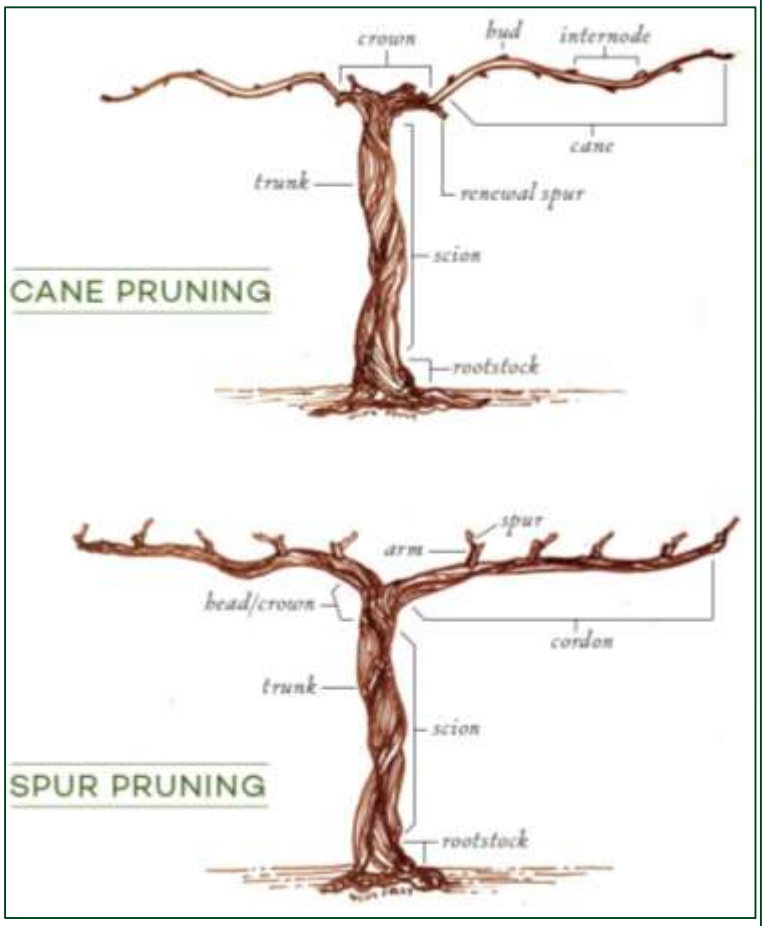
10. Canopy management

Training systems

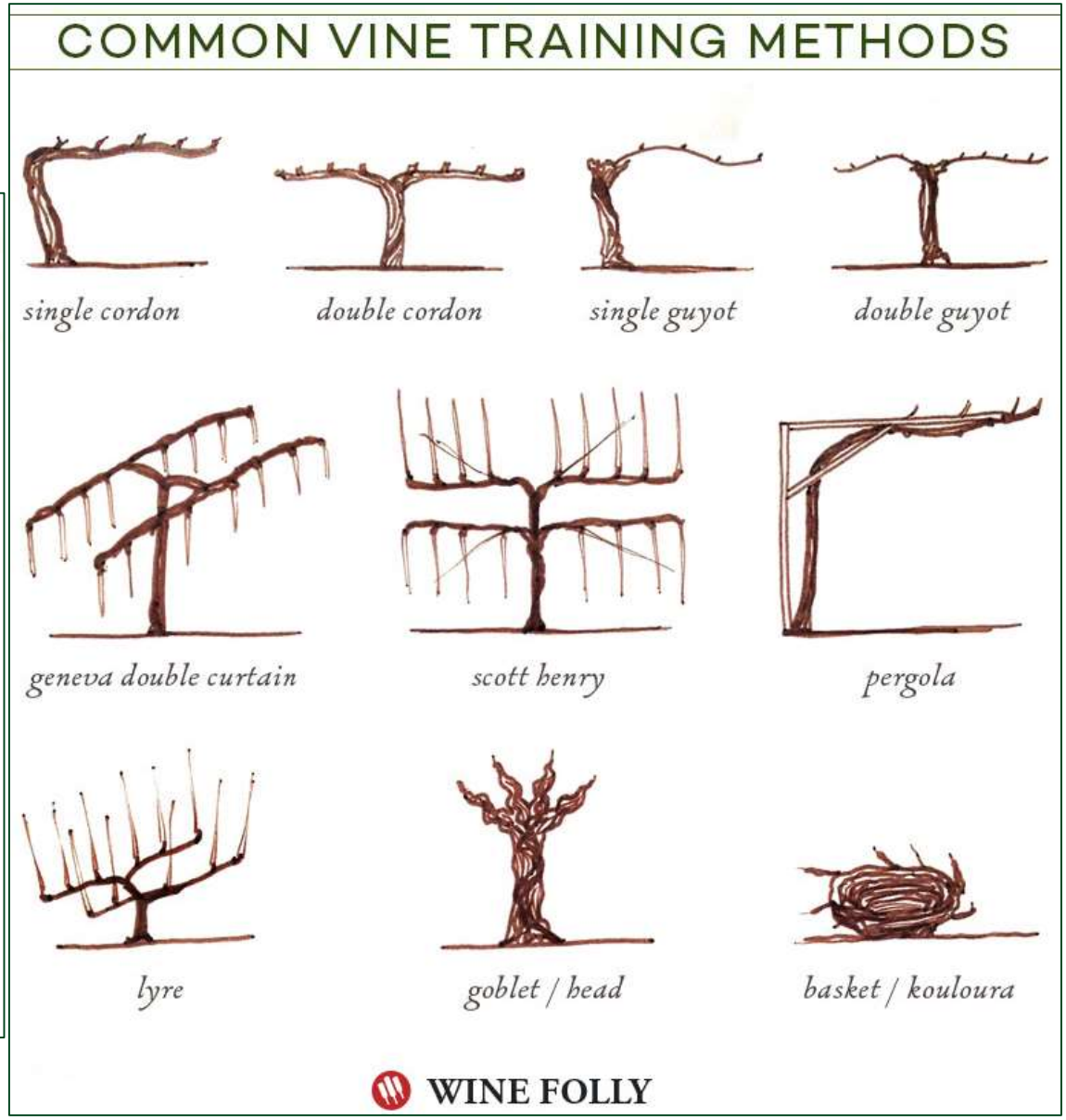
- Arrangement of the trunk and arms in space (it is done in the first 3-4 years)
  - **Types of training systems**
    - Based on the height of the trunk:
      α) Short, β) Medium height, γ) Tall vines
    - Goblet systems
    - Linear systems (Royat, Guyot, Sylvoz, Lyre, mixed modern)

10. Canopy management

Training systems



https://winefolly.com/deep-dive/grape-vine-training-methods-illustration/



10. Canopy management

Training systems

Goblet / Head

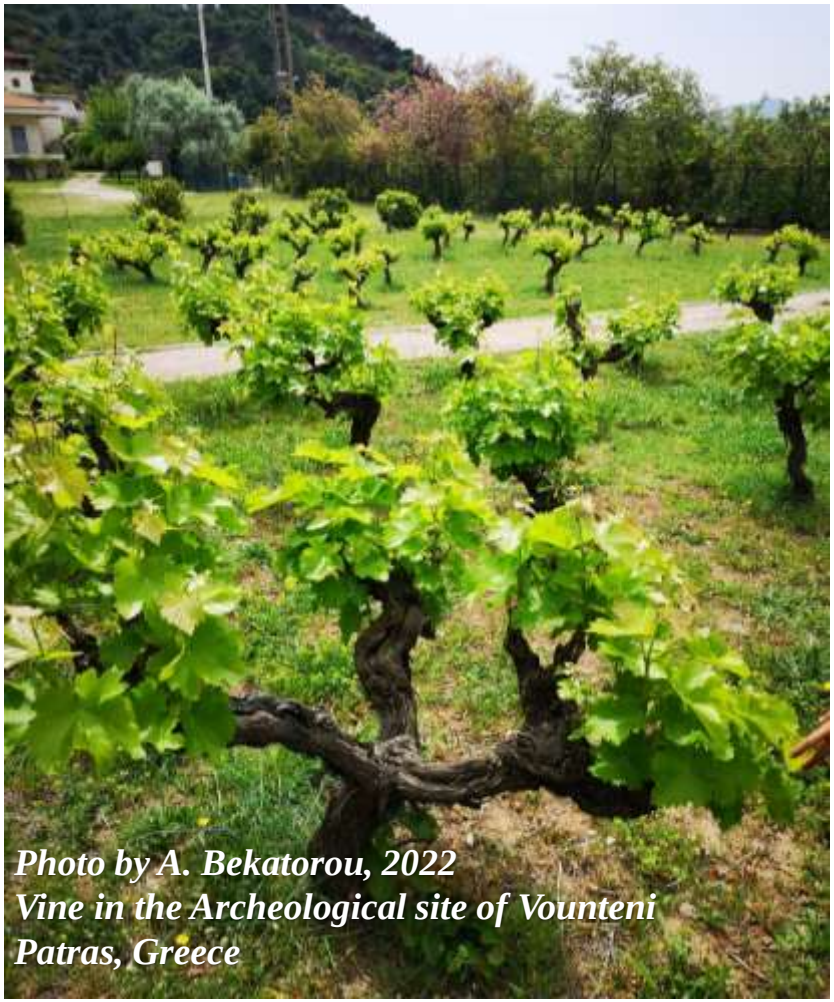
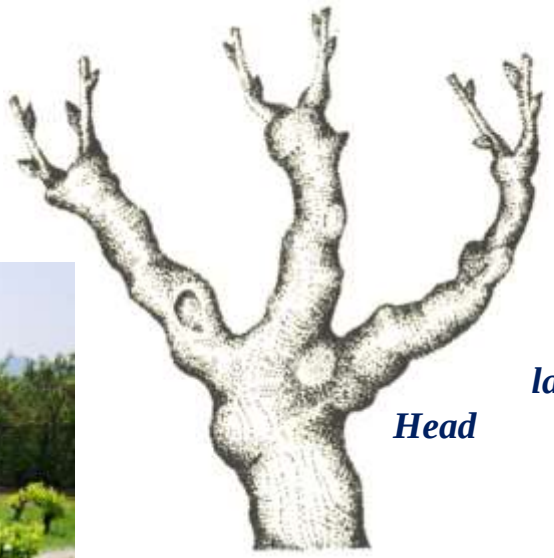
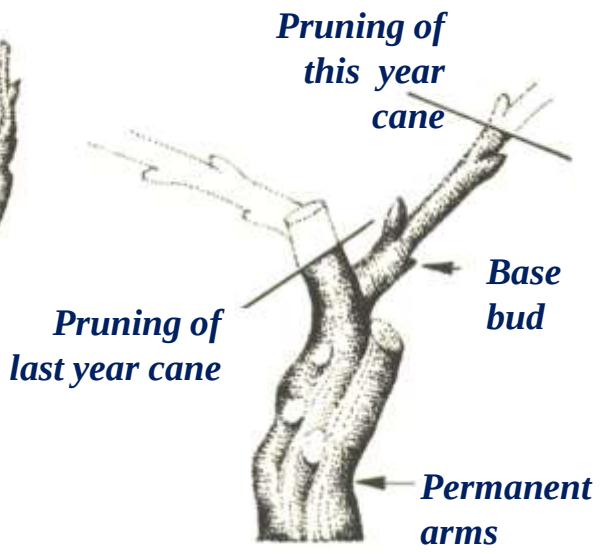


Photo by A. Bekatorou, 2022
Vine in the Archeological site of Vounteni
Patras, Greece

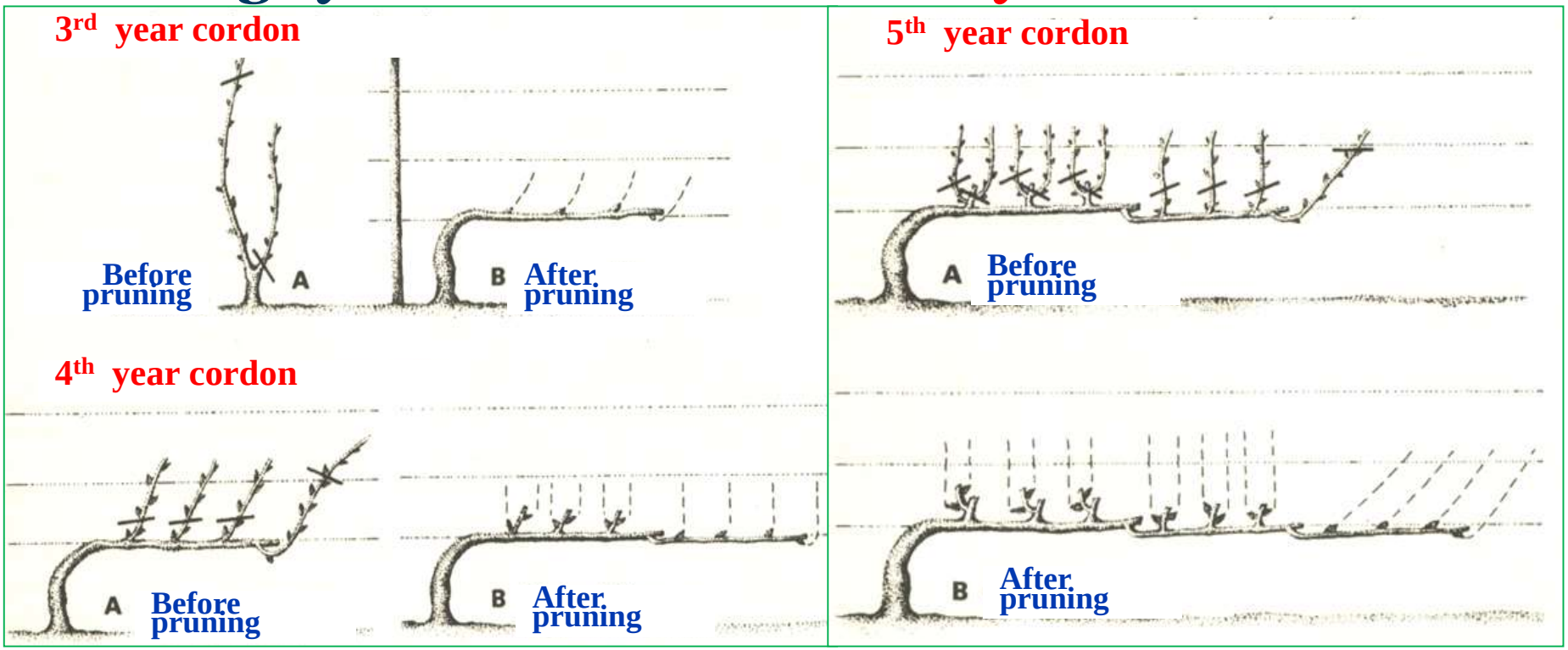




- Configuration without a trellis support
- Short shape
- Good quality grapes because the vine is closer to the ground
- The most common shape since antiquity

10. Canopy management

Training systems - Cordon de Royat




Single cordon


Double cordon

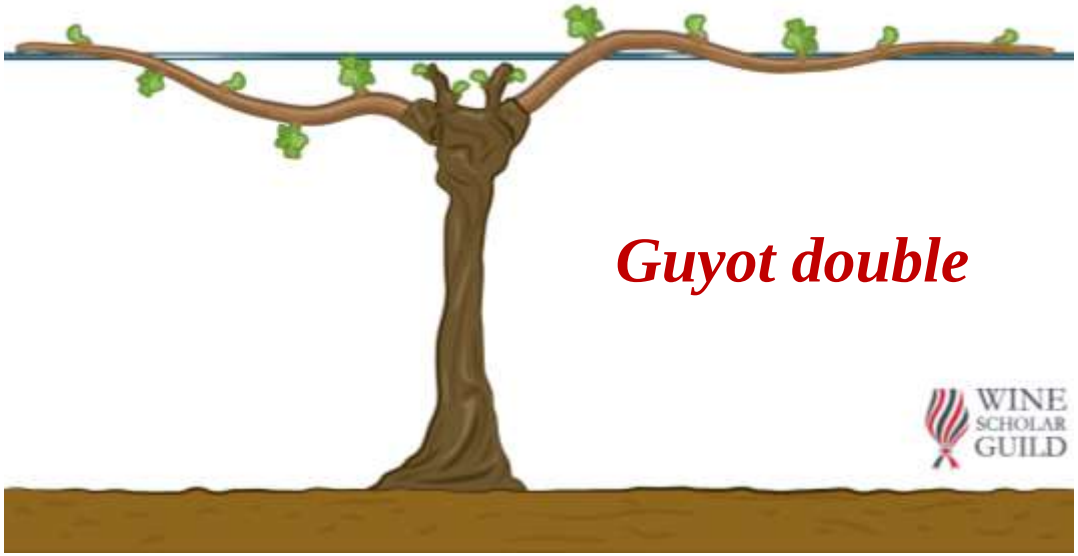
https://glossary.wein.plus/cordon-de-royat

http://www.dourthe.com/la-vie-de-nos-vignes/la-taille-une-facon-noble/

10. Canopy management

Training systems - Guyot

Guyot single



Guyot double

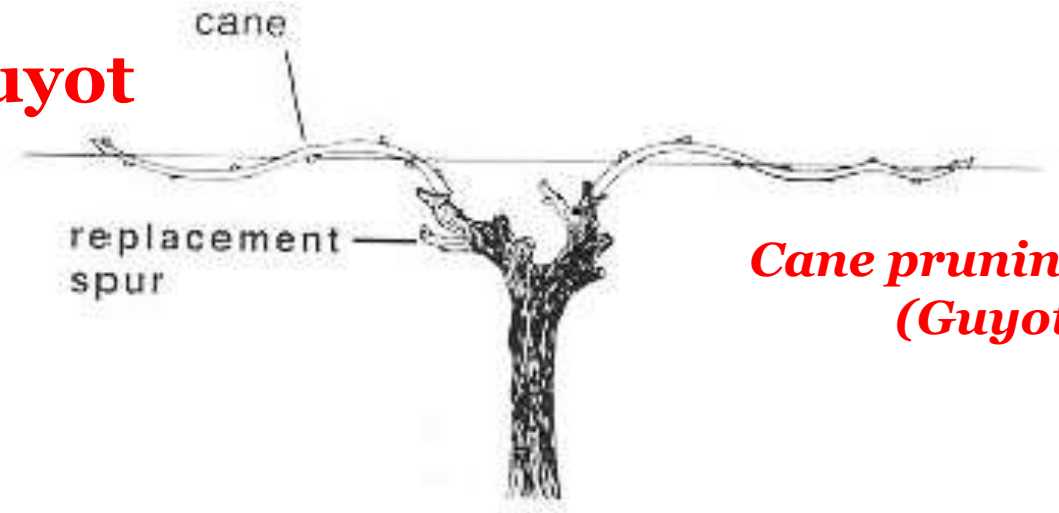
https://www.winescholarguild.org/blog/vine-school-part-1-common-vine-training-systems

10. Canopy management

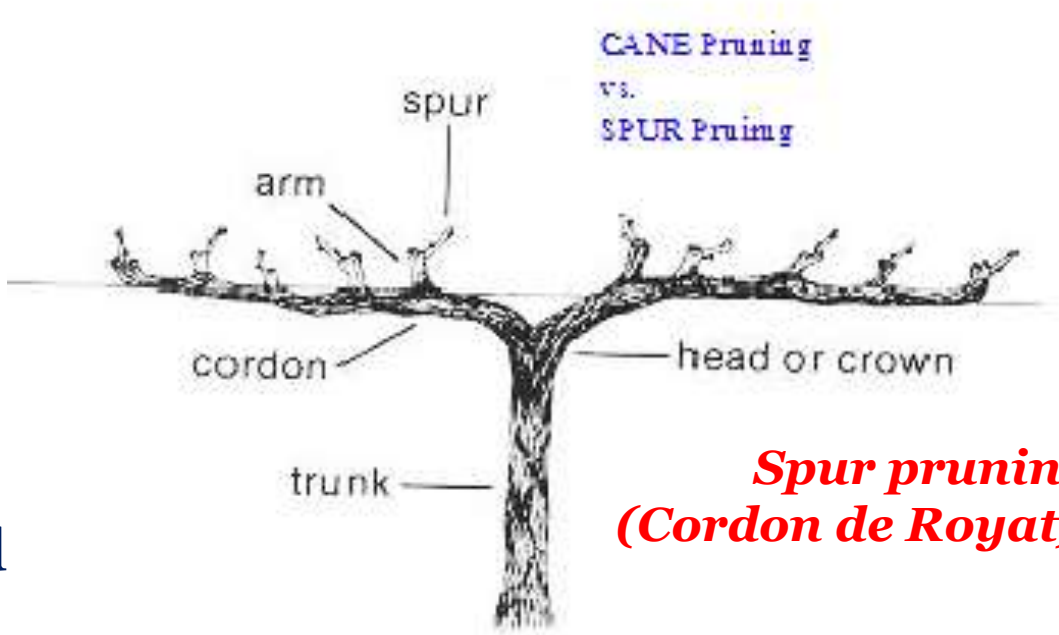
Training systems - Guyot

The Guyot system is similar to the Cordon (Royat):

- The vine is arranged horizontally along a trellis with either 1 or 2 arms.
- The difference lies in the pruning technique.
- Instead of leaving several spurs, Guyot vines are pruned to a single spur and 1 cane with 5-10 buds.



Cane pruning (Guyot)

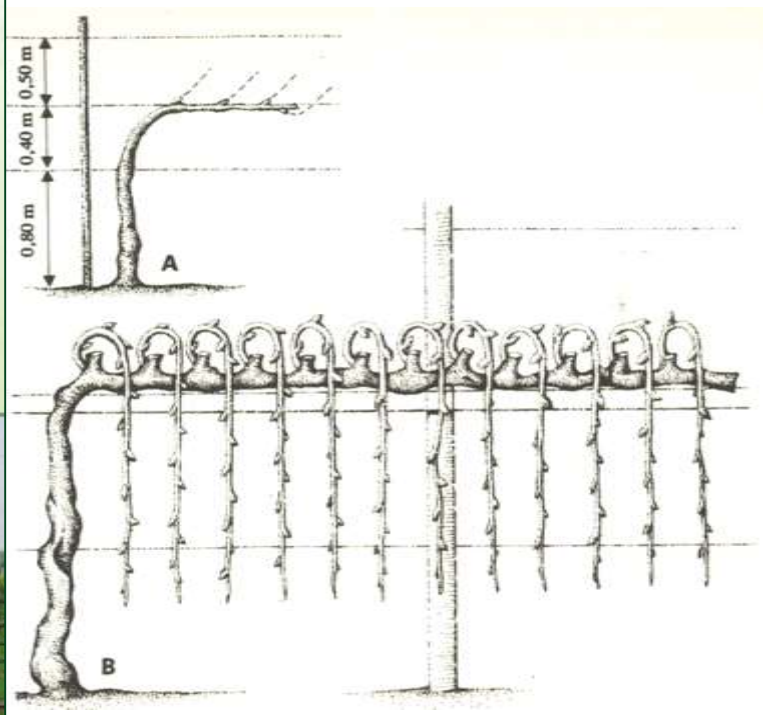


Spur pruning (Cordon de Royat)

https://thetastinggroup.wordpress.com/2013/03/27/todays-wine-word-pruning/

10. Canopy management

Training systems - Sylvoz



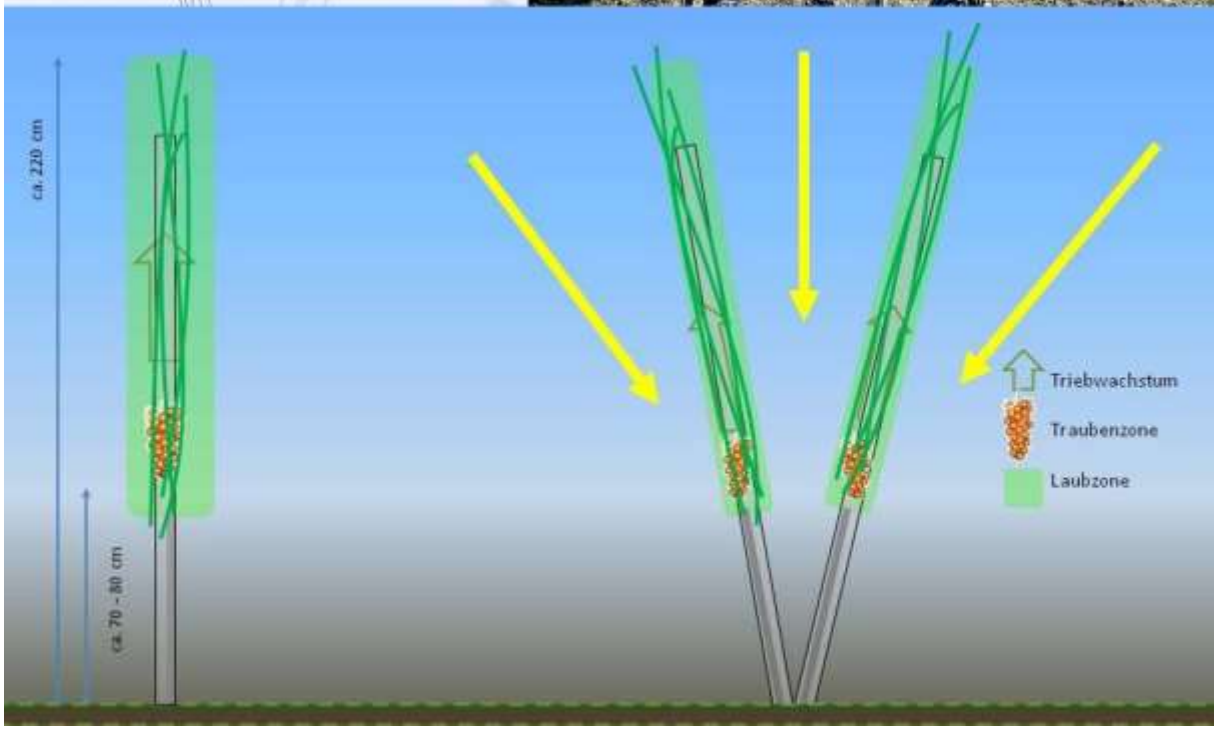
https://www.comavit.it/index.php?area=74&menu=31116&lingua=1

10. Canopy management

Training systems

Lyre

For optimization of sun light intake



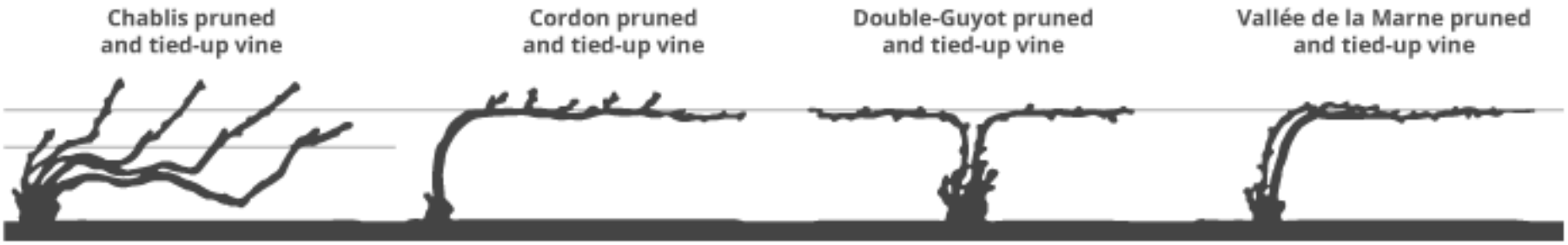
https://www.living4media.com/images/12304660-Grape-vines-grown-on-lyre-training-system-in-winter

https://www.goodfruit.com/matching-trellis-to-terroir/

https://glossary.wein.plus/lyre-1

10. Canopy management

Training systems – Champagne systems



- **Chablis system:** cane pruning, leaving short bud-bearing canes.
- **Cordon system:** spur pruning on a single permanent 'cordon'.
- **La taille Guyot:** cane pruning, keeping one cane and one spur per vine (**Single Guyot**) or two canes and two spurs per vine (**Double Guyot** and **Asymmetric Guyot**).
- **La taille Vallée de la Marne (Pinot Meunier only):** cane pruning (similar to Guyot system).

https://www.champagne.fr/en/from-vine-to-wine/vine-husbandry/pruning

10. Canopy management

Green pruning

(performed between spring and summer in order to remove excess vegetation)

Aims of the green pruning:

- To maintain the balance between fruit load and vegetation
- To maintain the productivity of the plant
- To ensure the quality of grapes
- To maintain the canopy shape

Types of green pruning:

- **Short** (up to 3 buds)
- **Long** (cordons with 5-10 buds)
- **Mixed**

In wine varieties, short pruning is usually applied

10. Canopy management

Green prunings

- **Spur/cane pruning**
- **Tip pruning** (or pinch pruning – removal of the shoot tip)
- **Defoliation** (foliage thinning)
- **Girdling** (ring-barking), i.e. complete removal of a ring of bark
- **Cluster thinning** (removal of some immature fruit clusters)
- **Use of plant growth regulators**

10. Canopy management

Criteria for evaluating the effectiveness of vegetation

- **Relationship between Active Leaf (Foilar) Area and grape load:**
  8-12 cm^2 ALF/ gram of grapes

- **Relationship between Total Leaf Area and the corresponding Outer Leaf Area:**
  TLA / OLA = 1.5

- **Shoot density: 15-20 shoots / m^2**

- **Fruit Load weight / Pruning wood (Ravaz Index):**
  <5 incomplete pruning, >10 excessive pruning

- **Robustness: 300-600 g/m**

Viticulture

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Grapes - John - Clive Dawson - Squibb

Thank u!!!