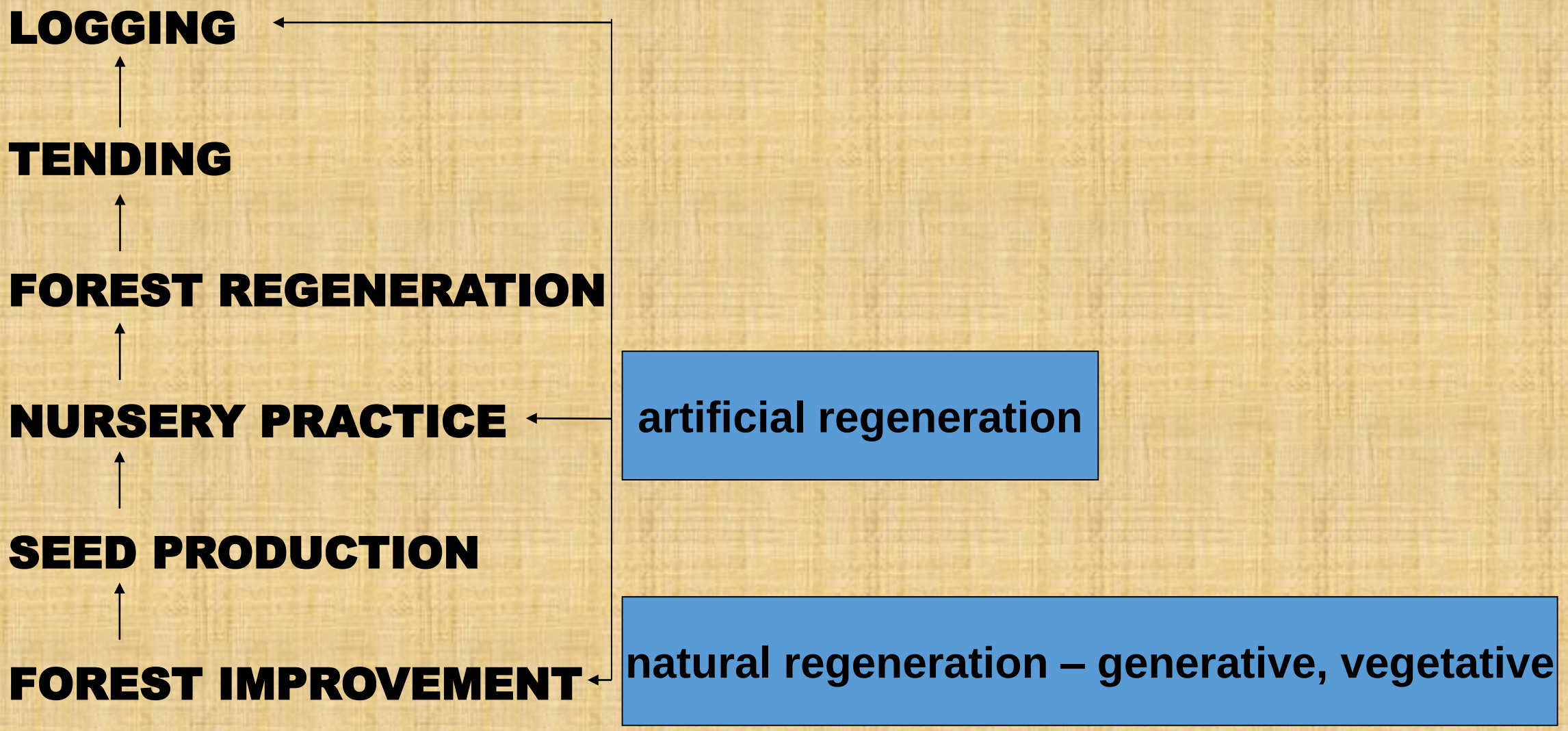
Planting stock of tree species

Silviculture

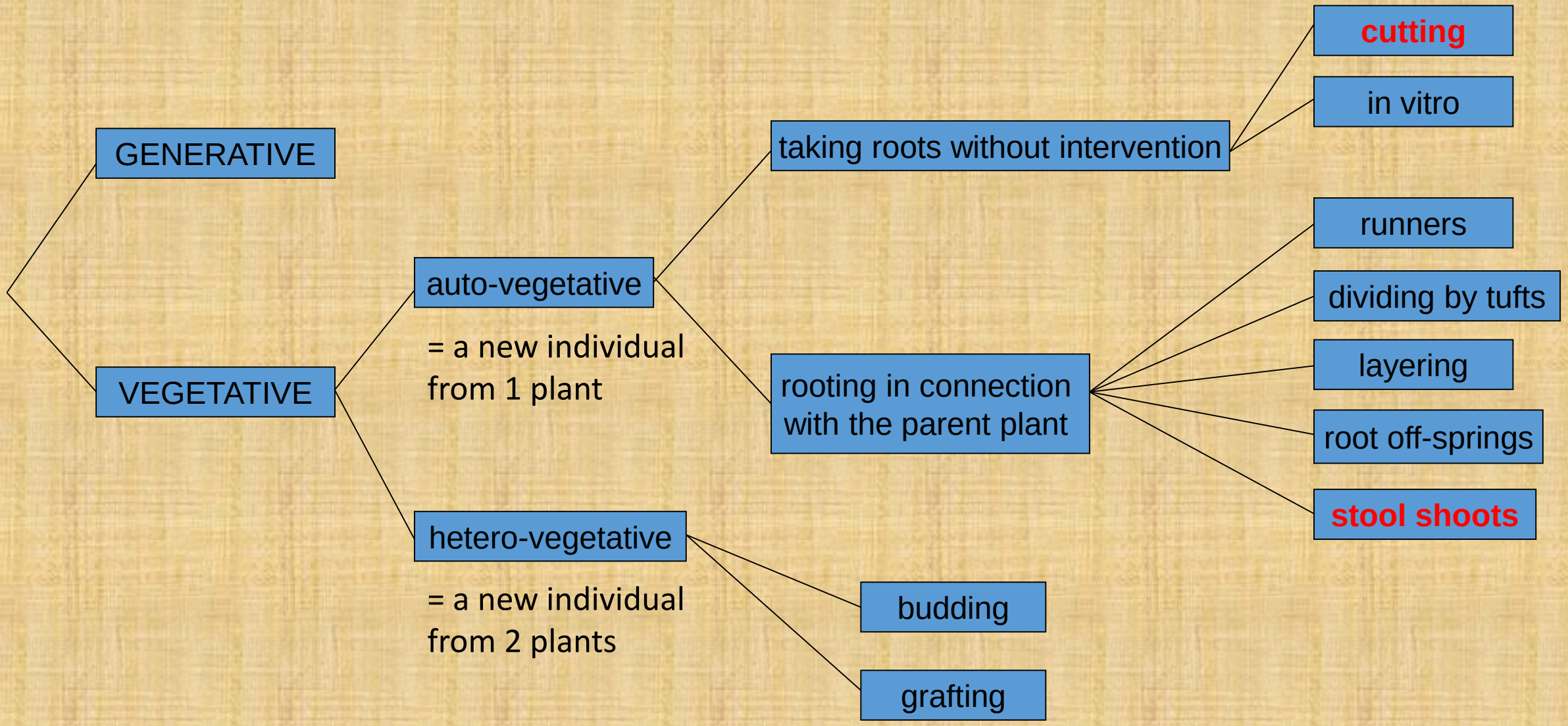


CLASSIFICATION OF PLANTING STOCK

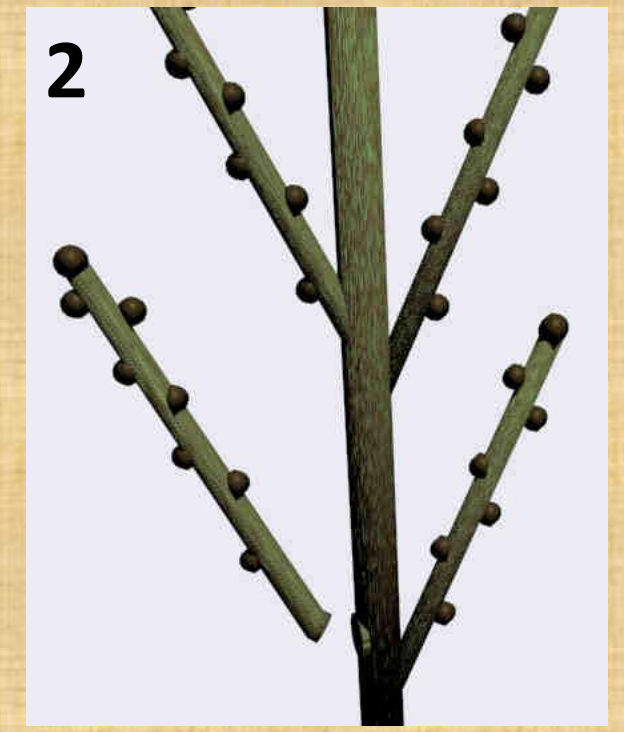
1. BY ORIGIN

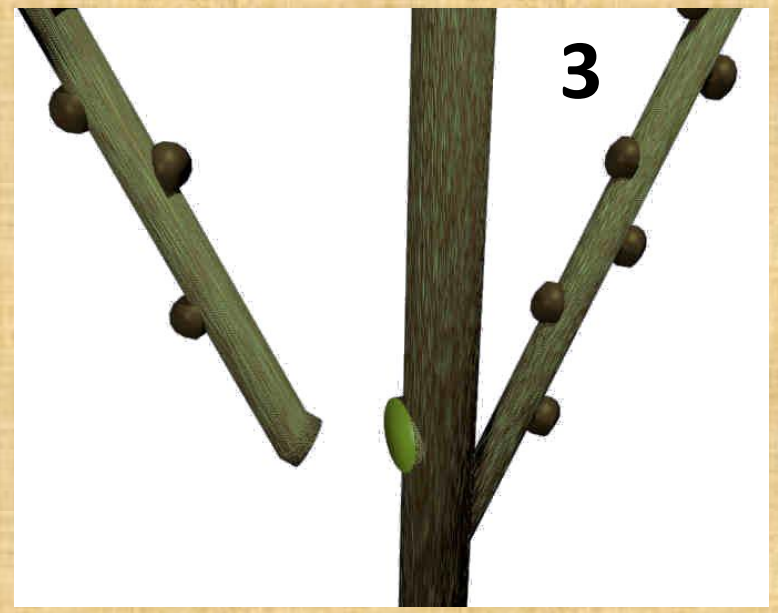
- **Generative**
  - grown from seeds
- **Vegetative**
  - grown from parts of plants (cuttings, grafts etc.)
  - ***Positive***
    - we know what characteristics will develop in the plant
  - ***Negatives***
    - this is a clonal multiplication => possibility of narrowing the gene pool, in forestry only with the permission provided by the state administration; in fruit growing and ornamental nurseries the main method of cultivating of the planting stock

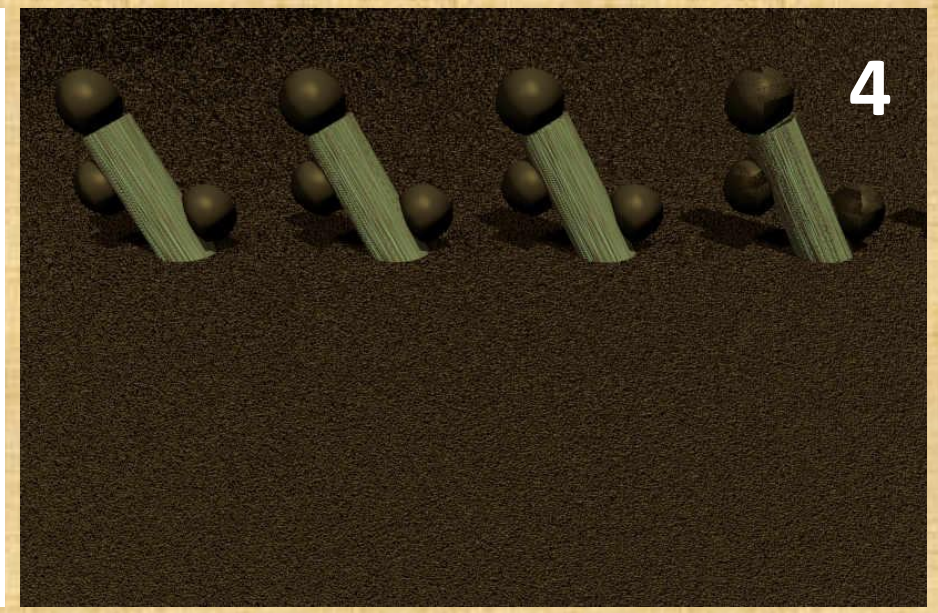
CLASSIFICATION OF PLANTING STOCK – by origin

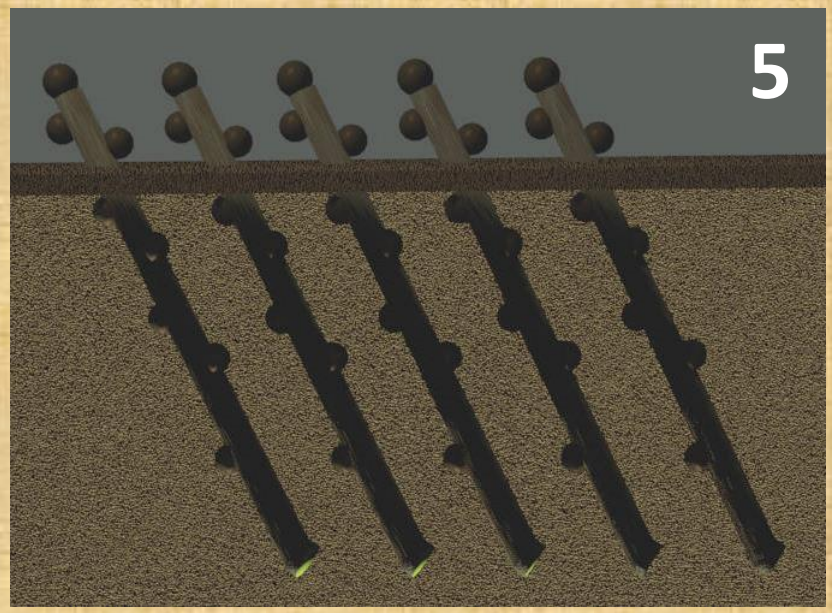


CUTTING

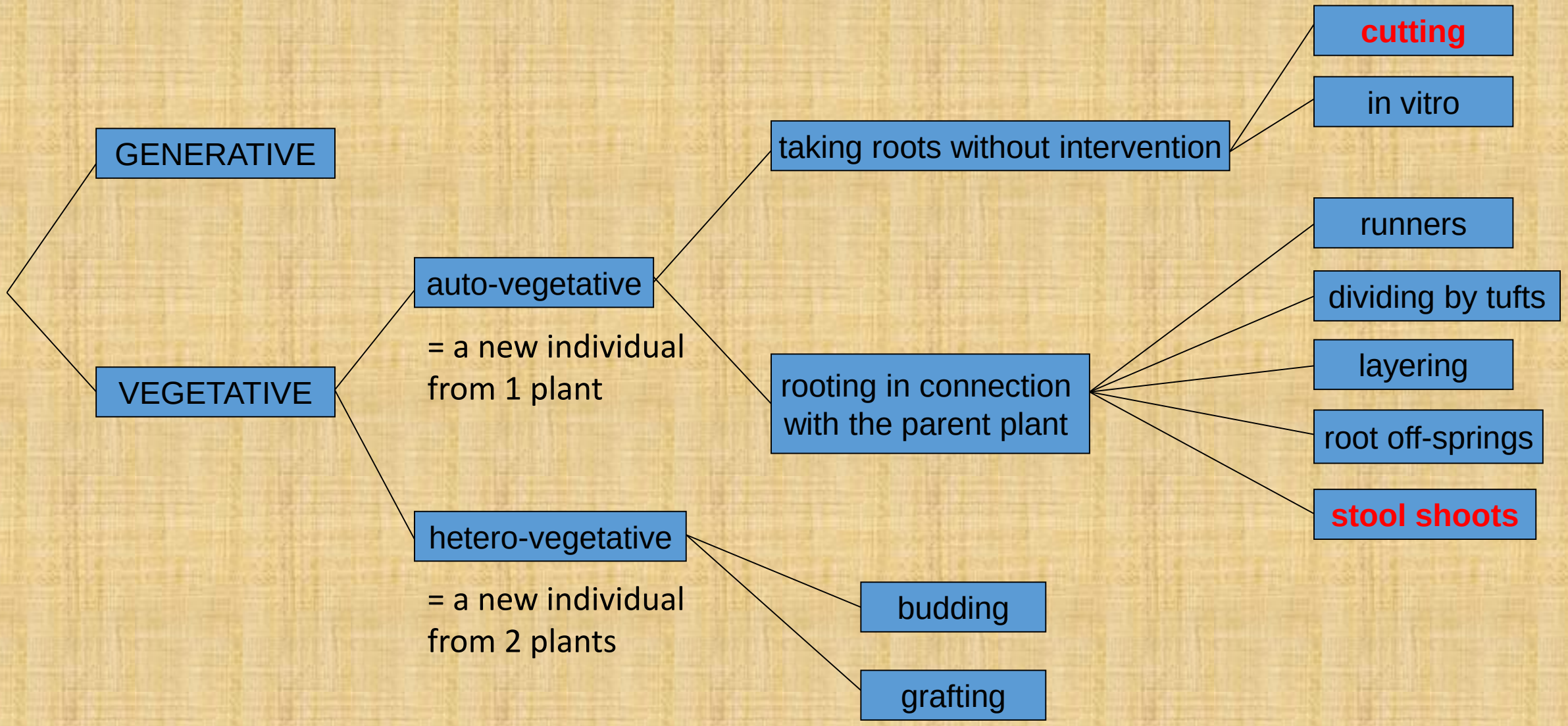








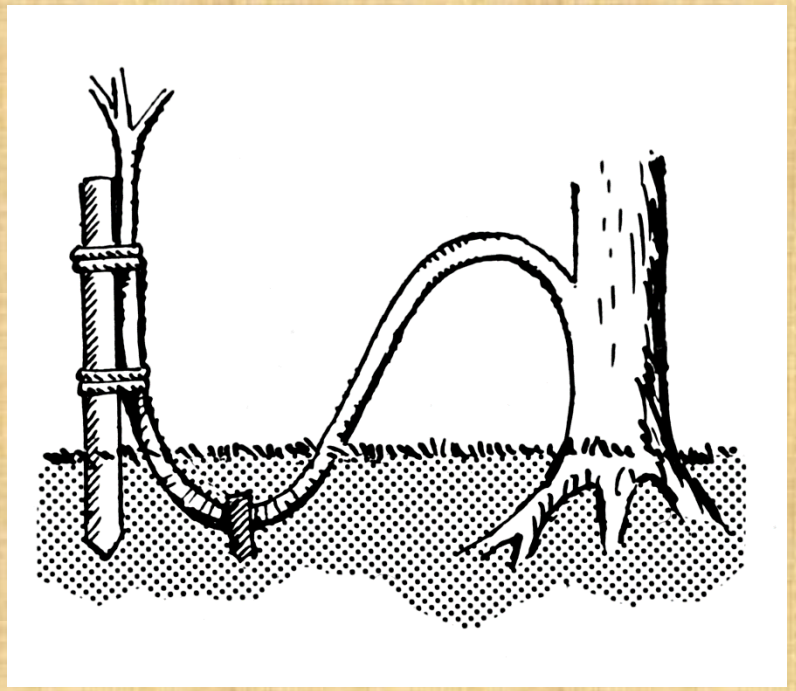
CLASSIFICATION OF PLANTING STOCK – by origin



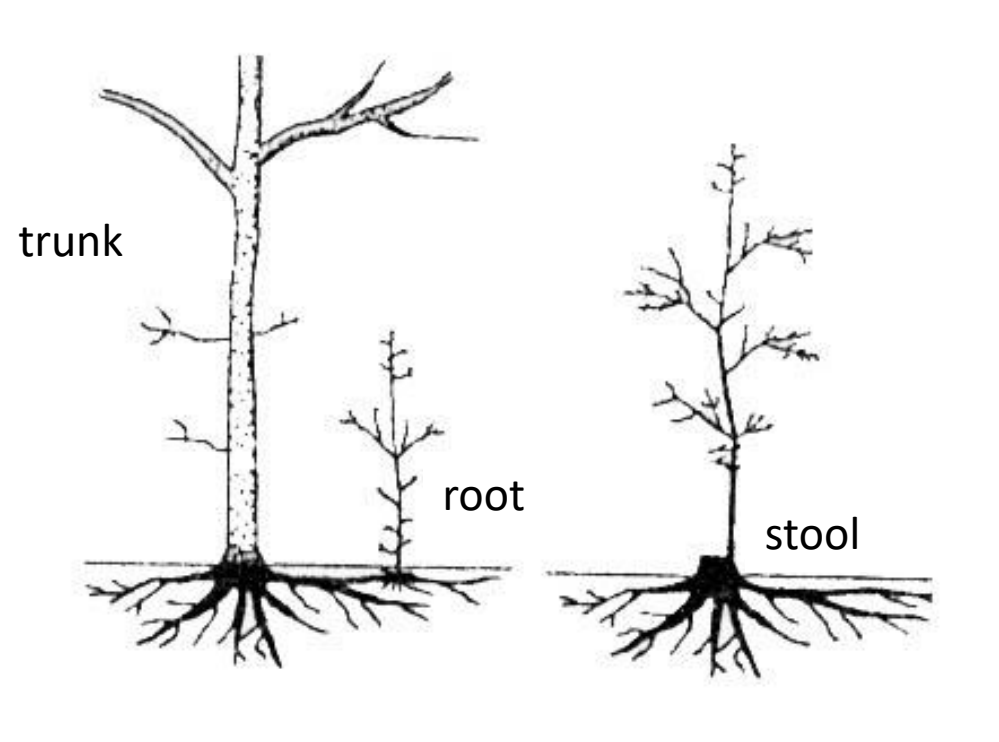
RUNNERS

DIVIDING BY TUFTS

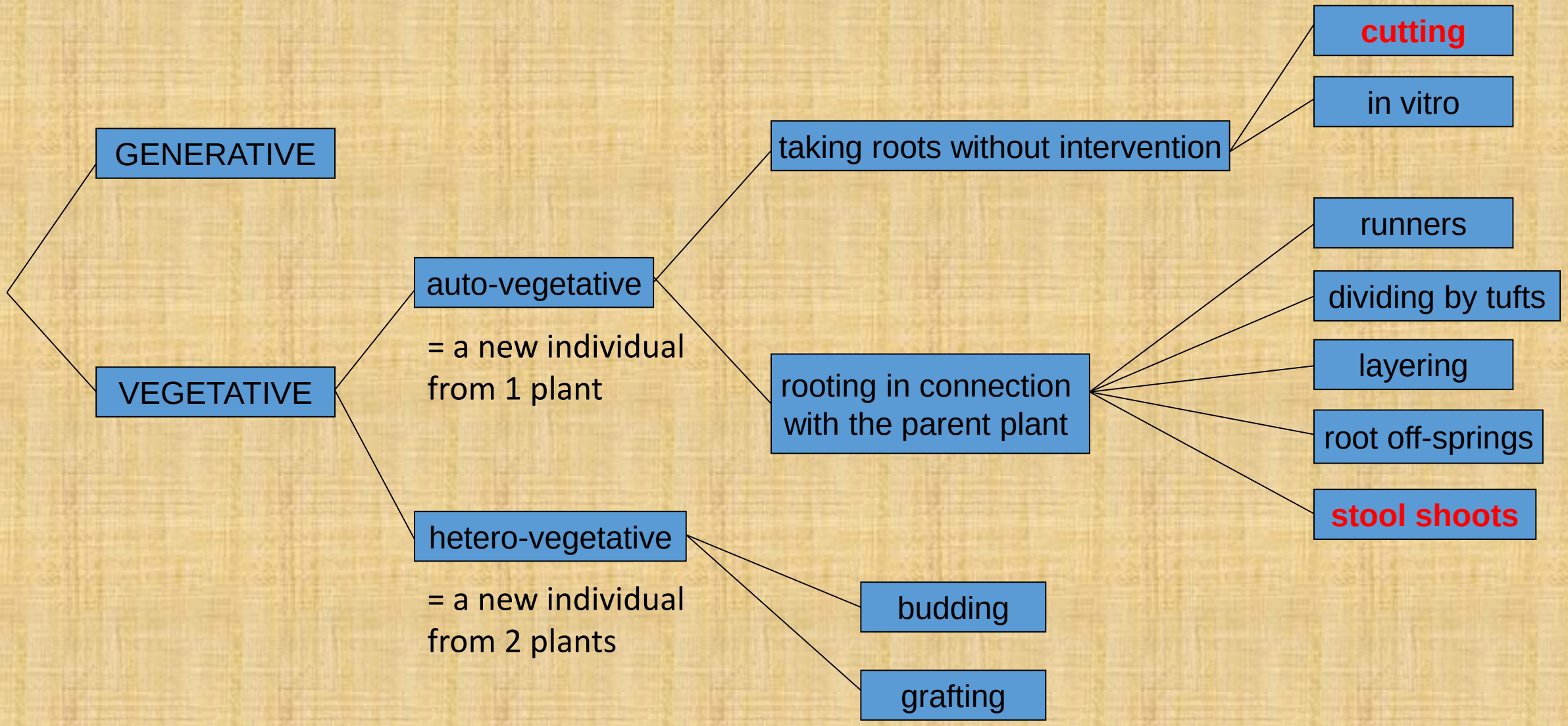
LAYERING



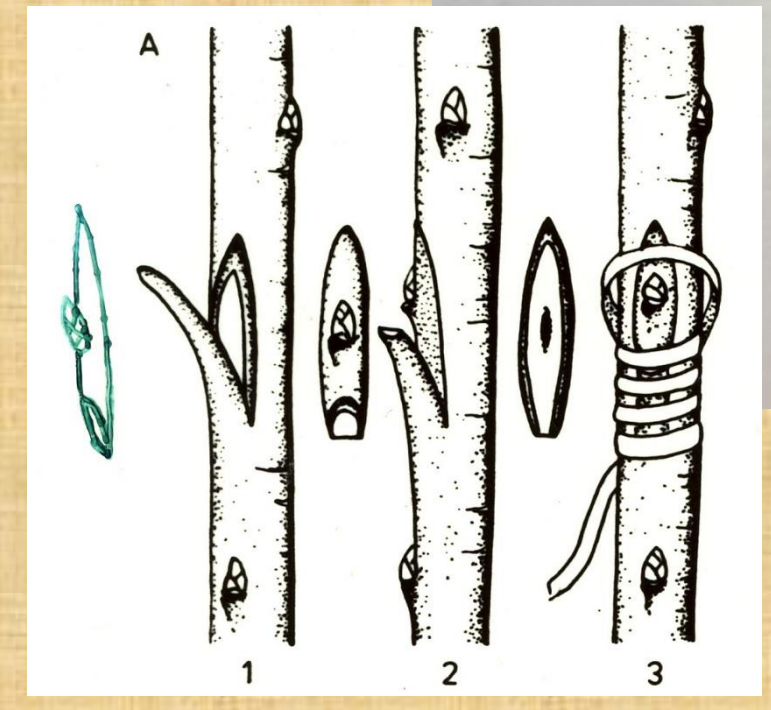
TRUNK X ROOT X STOOL SHOOTS/OFF-SPRINGS



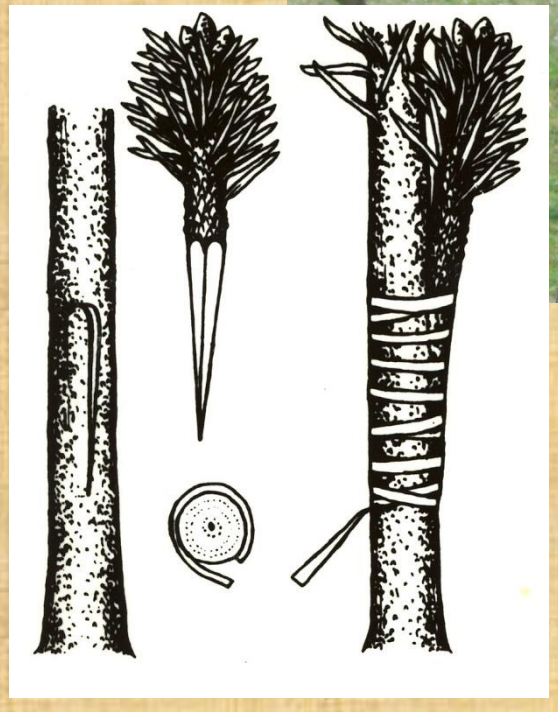
CLASSIFICATION OF PLANTING STOCK – by origin



BUDDING



GRAFTING



2. BY THE PROTECTION OF THE ROOT SYSTEM

- **Bare-rooted**
  - **The root system is not protected (it is “bare”)**



- **Containerized**
  - **The root system is wrapped in substrate or soil (placed in a “root ball”)**



- ***Positives: Containerized planting stock***
  - **The root ball protects against mechanical damage or drying out**
  - **The root ball contains a reserve of water and nutrients => lower mortality, better growth => quickly developed stand**
  - **Used in worse localities**
  - **The number of planted individuals can be reduced**
  - **Forest planting is possible all the year round, with some exceptions**
    - **Frozen or muddy (too much water) soil**
    - **During periods of dryness, before late frosts**
    - **During this year's growth of terminal increment**
- ***Negatives: Containerized planting stock***
  - **Up to now higher price**
  - **More expensive transport**
  - **Risk of deformation of the root system**

- **Classification of containerized planting stock**

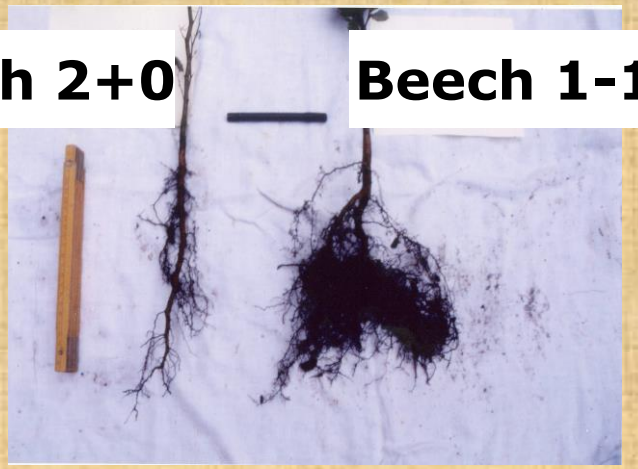
  - **Clod** (the plant is lifted from the soil with a hollow spade or special tool, the wrap is fixed)

  - **Packaged** (the substrate is mechanically pressed onto the root system => extensive deformation of the root system)

  - **Containerized** (wrapped) (the plant is grown in a solid container)

THE MAIN PROBLEM (OR ART) OF THE QUALITY PLANTING STOCK CULTIVATION

- **It is easy to grow the planting stock tall above ground – the plants are fertilised**
- **The art is to develop a quality root system by these techniques:**
  - **Applying of phytohormone**
    - **Not suitable for the forest, nobody knows how the trees will develop later**
  - **Mechanical adjustment of the root system**
    - **After the mechanic adjustment (cutting), several new roots will develop at the cutting point; at the same time, the growth increment of the part above the ground decreases and the trunk gets thicker. Technologies – transplanting, undercutting, moving into a container.**

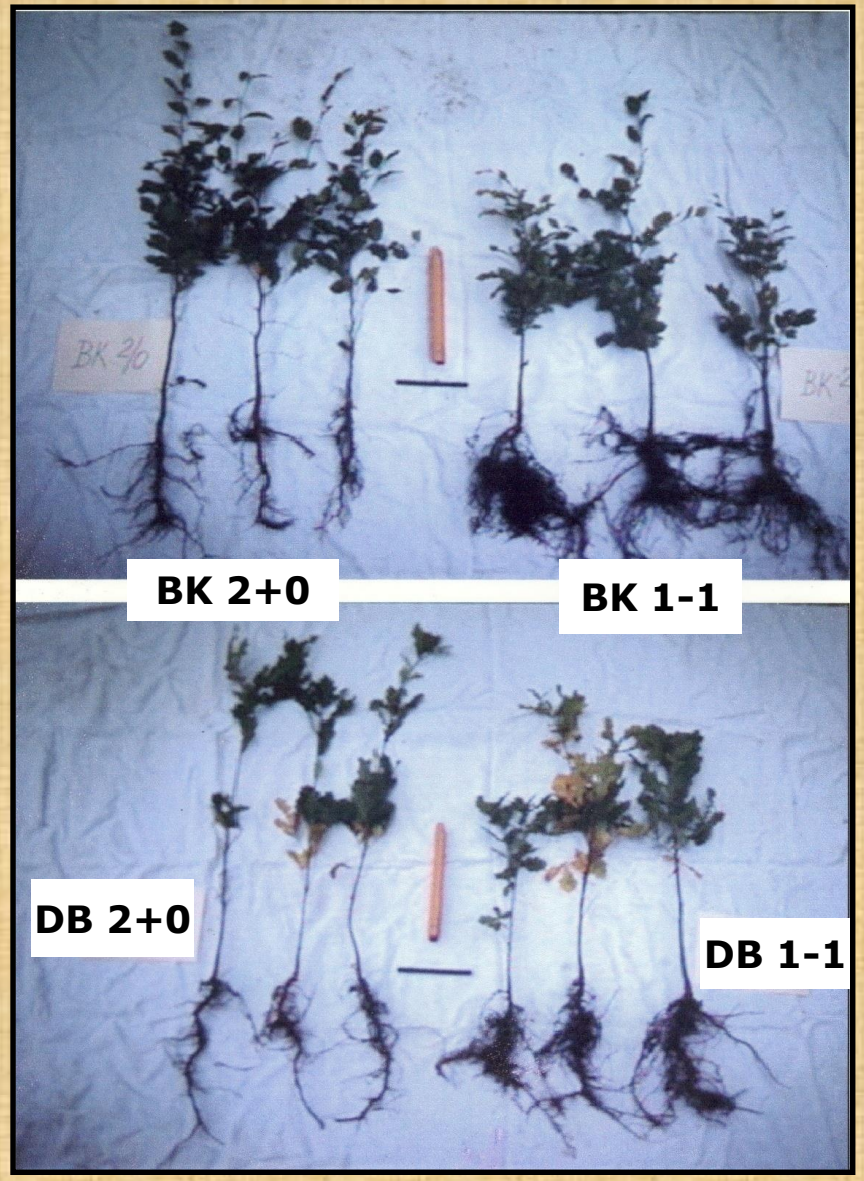


3. BY MORPHOLOGICAL PARAMETERS

COMPACT PLANTING STOCK

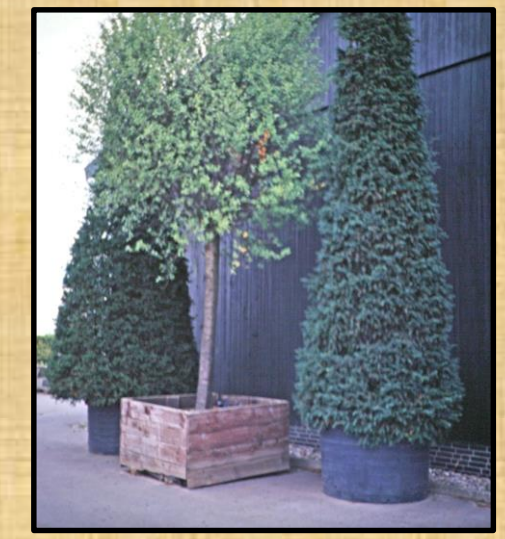
- ***Seedling***
  - **Plant without mechanical adjustment of the root system, above ground part height max. 80 cm**
  - **Has a very week root system, bare-root - suitable for good locations; small individuals can be planted in dry places. Containerized broadleaves, pine and larch - standard planting stock**

- ***Plant (Transplant)***
  - **An individual with one mechanical adjustment of the root system, the above ground part height max. 70 cm**
  - **Most frequently used planting stock**



- ***Large-sized plant***
  - **A plant with two mechanical adjustments of the root system - height of above ground part: coniferous trees 51 to 120 cm, broadleaves 81 to 120 cm, or with shaped crown**
  - **Very sensitive (vulnerable) planting stock, used only for good locations and repair planting**

- ***Sapling***
  - **A plant with at least two adjustments of the root system, above ground height 121 to 250 cm, with shaped crown**
  - **Used only for special-purpose planting**



- ***Full-grown tree***
  - **A plant of above ground height more than 250 cm, with multiple adjustments of the root system and adjustment of the above ground part, several tens years old.**

PLANTING STOCK WITHOUT ROOTS

- **Used only in fast growing trees (*Populus*, *Salix*) and in fast rooting trees (*Corylus*, *Carpinus* etc.)**
  - **Standard cuttings – one year old wood, diameter up to 3 cm and length 40 cm – with or without terminal bud**
  - **Branches and bunches of branches (wisps) – often cut directly from the trees in the forest**
  - **Sticks (planting rods) – "cuttings", diameter up to 3 cm and length up to 1.5 m**
  - **Poles – "cuttings", diameter more than 3 cm and length up to 8 m**
- **Cuttings with terminal bud, branches, sticks and poles are put into the soil with their basal part**
- **During the planting procedure the plant must not be mechanically damaged (the holes in the soil are made before we place the plant)**
- **Usage – very high and low groundwater level, slope stabilization, energy forests, forest tree improvement**

SNAG PLANTING STOCK

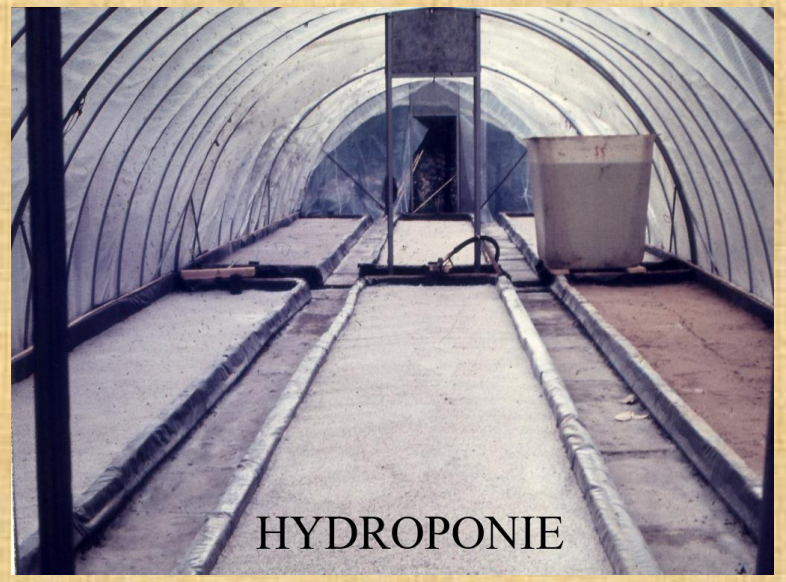
- **The above ground part (above the bud) is removed before planting (in the nursery)**
- **Usage – very dry locations, when establishing coppices**

4. BY THE CULTIVATION TECHNOLOGY

- ***Standard technology***
  - **The planting stock is cultivated under the open air in mineral soil for the whole time**
  - **Partial regulation of nutrient and water, no weather regulation**

- ***Glasshouse, (plastic) greenhouse, hot bed (forcing frame)***
  - **The planting stock is cultivated in artificial substrate and controlled environment**
  - **Medium regulation of nutrition and water, medium regulation of environmental factors**

- ***Hydroponics***
  - **The planting stock is cultivated in water (with nutrients) and controlled greenhouse environment**
  - **Complex regulation of nutrients and water, medium regulation of environmental factors**



- ***In vitro (explantate culture)***
  - **The planting stock is cultivated in fully artificial and controlled environment of a laboratory – in vitro**
  - **Full regulation of all growth factors and environment**

- **Combination of the technologies as above (e.g. seedlings are cultivated in greenhouses, after that standard technology is applied)**

- **Due to increasing intensity of technological approach, plants can be of physiologically lower quality; therefore, never use them for direct forest regeneration; preferably - in the final stage, cultivate them with standard technology or harden the plants off in the open air - at least 2 months**

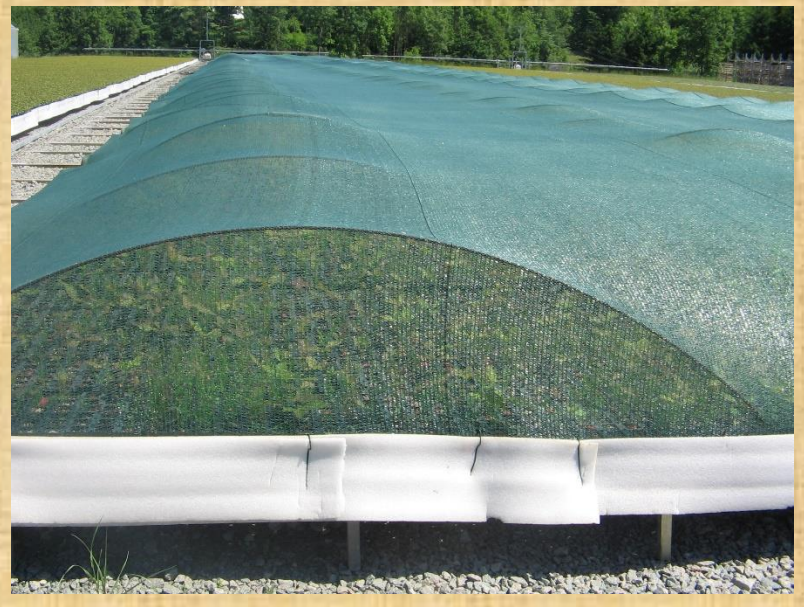

1


2

3

BASIC PRINCIPLES OF THE TECHNOLOGIES USED FOR CULTIVATION OF PLANTING STOCK

- **the common feature for all technologies: the nursery is without <u>weed;</u> the planting stock is <u>irrigated</u> (watered), <u>fertilized</u> as needed; it is necessary to protect plants against <u>diseases, pests and abiotic agents</u>**



1. CULTIVATION OF BARE-ROOTED PLANTING STOCK IN STANDARD FOREST NURSERY

- **The planting stock is cultivated in mineral soil, in the open air**
- **Cultivation of bare-rooted seedlings**
  - **Seeds are sown in the mineral soil. As soon as seedlings have the necessary above ground height, they are lifted from the soil and further used for forest regeneration (unsuitable – their root system is weak), for transplanting (the resulting product is a bare-rooted transplant), or they are transplanted to containers (the resulting product is a containerized plant)**

- **Cultivation of bare-rooted transplants**
  - **The root system of the lifted bare-rooted seedlings is manually cut and they are transplanted to mineral soil in regular spacing; containerized seedlings can be transplanted as well. Bare-rooted plants can be cultivated by the so-called undercutting of their roots – the bare-rooted seedlings are not lifted from the soil but their root system is shortened with special knives (machines) directly in the soil**

- **Cultivation of plants by rooting**
  - **Natural seedlings are lifted, whose shoots are developed enough to be planted. To enlarge the root system, after mechanical adjustment (cutting) of the root system they are “transplanted” for 1 year in an irregular spacing**
  - **The conventional planting stock can be rooted and undercut in addition as well**

- **Cultivation of bare-rooted large-sized plants and saplings**
  - **The root system of the lifted bare-rooted plants is manually cut and they are transplanted back to the mineral soil; containerized plants may be transplanted as well. The plants can be also cultivated by undercutting of their root systems.**

Sorbus aucuparia

Fagus sylvatica

Acer pseudoplatanus

2. CULTIVATION OF BARE-ROOTED SEEDLINGS IN GLASSHOUSES OR (PLASTIC) GREENHOUSES

- **Planting stock can be cultivated in artificial organic substrates (peat, bark) and controlled environment. The following factors are regulated: air temperature and humidity, substrate temperature and humidity, intensity, spectral composition and light wavelength, CO_2 concentration in the air, nutrients**

- **The controlled conditions significantly increase the seed yield (compared to the cultivation in a standard nursery, it is possible cultivate up to three times more plants from the same amount of the seed lot); it is possible to grow up to 3 generations of seedlings in the same year**
- **The seeds are sown in the prepared substrate. As soon as the seedlings have the necessary above ground height, they need to be hardened off in the open air (the foil is removed, the seedlings are moved outside the greenhouse at the holding area). When seedlings are lifted from the substrate, their root system is cut; they are further used for forest regeneration (unsuitable – their root system is weak); for transplanting to mineral soil (the resulting product is a bare-root transplant), or they are transplanted to containers (the resulting product is a containerized plant)**

3. CULTIVATION OF CONTAINERIZED PLANTING STOCK

- **The plants are cultivate separately, in solid containers. Basic types of the containers: they either allow the roots penetrate through (paper, peat, textile containers), or not (plastic containers). The containers not allowing the roots penetrate through may cause absolute inacceptable deformation of the root system; therefore, they are often bottomless, their sides are perforated and ribs are added onto their inner side to prevent the deformation (the roots are turned). The size of the container must correspond to the shape of the root system and to the height of the shoot (this is defined by legislation).**
- **The containers that allow roots penetrate through are not removed, while the impermeable containers must be removed before planting and they can be reused.**

CULTIVATION OF CONTAINERIZED PLANTING STOCK – types of containers

WRAPS

- SINGLE

- CONTAINER

WRAPS

- ALLOWING ROOTS PENETRATE
  - textile

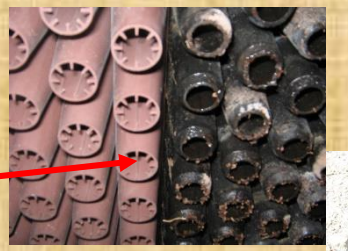
  - paper

  - jute

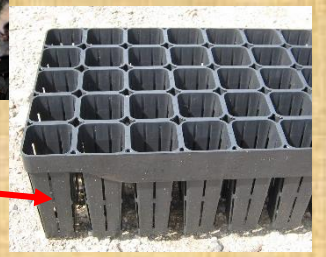
  - bobbinet

  - peat (coconut fibre)

- NOT ALLOWING ROOTS PENETRATE
  - with bottom
  - without bottom



  - with perforated sides



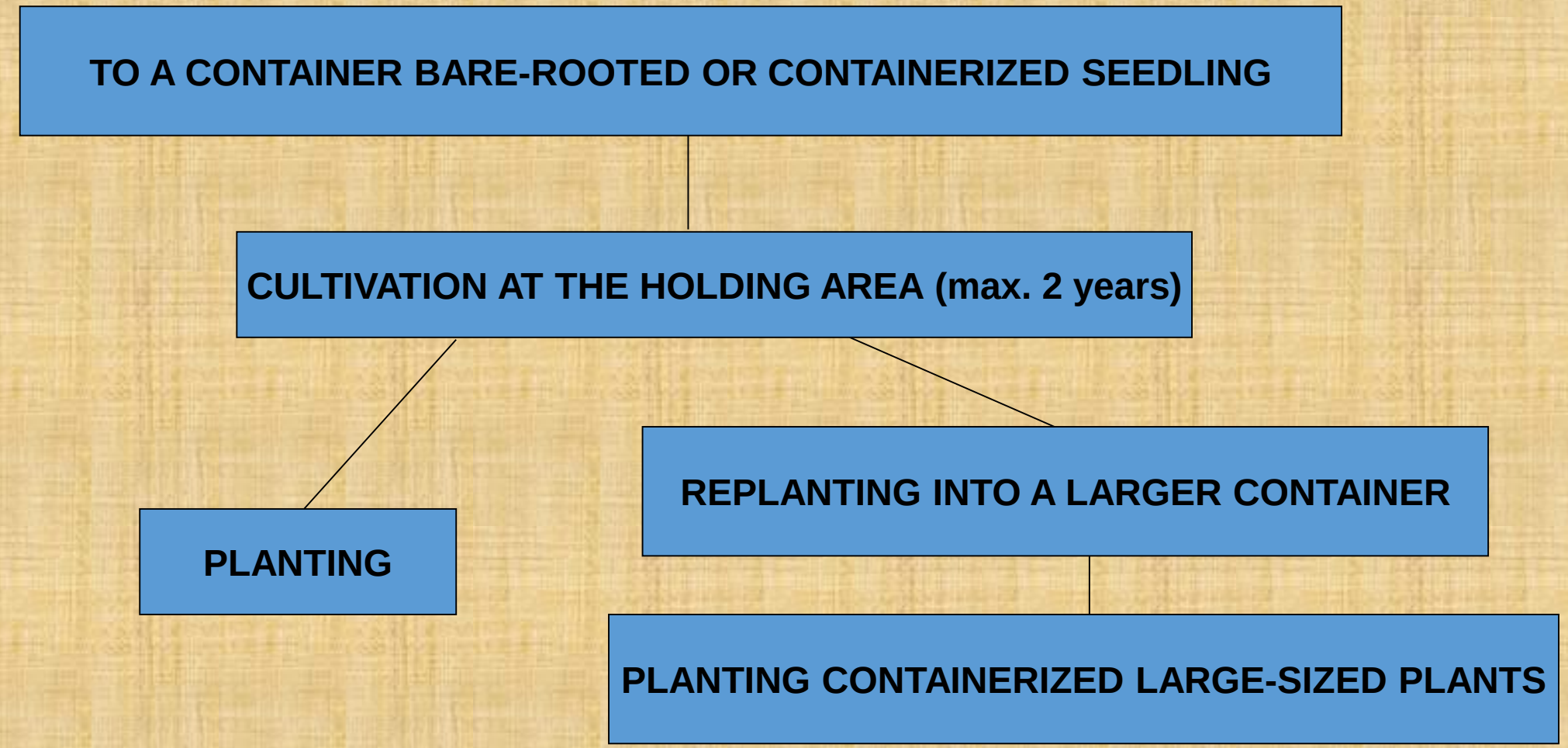
- **Cultivation of containerized seedlings**
  - **they are grown in the same way as the bare-root seedlings in glasshouses, greenhouses but in containers**
- **Cultivation of containerized plants**
  - **containers are used for containerized or bare-root seedlings; when we transplanted them, the plants are immediately placed in the open air or on a hardened surface of the nursery, the so-called holding area**
- **Cultivation of containerized large size plants and saplings**
  - **containers are used for bare-root or containerized plants; when we transplanted them, the plants are immediately placed in the open air or on a hardened surface of the nursery, the so-called holding area**

CULTIVATION TECHNOLOGY FOR CONTAINERIZED SEEDLINGS

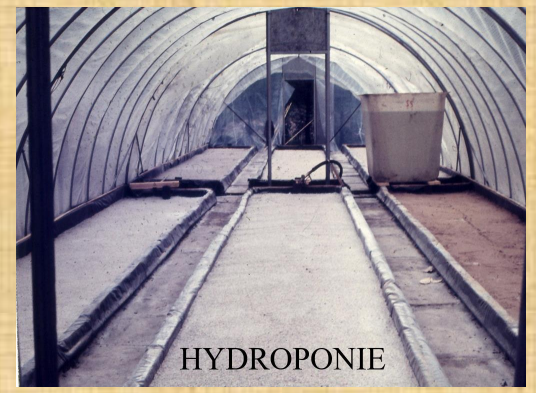
SOWING INTO A CONTAINER – ARTIFICIAL COVER (MAXIMUM: 1 YEAR)

- **HARDENING OFF – PLANTING OF SEEDLINGS**
- **TRANSPLANTING – PLANTING BARE-ROOT PLANTS**
- **TRANSPLANTING INTO A CONTAINER – PLANTING CONTAINERIZED PLANTS**

CULTIVATION TECHNOLOGY FOR CONTAINERIZED PLANTS

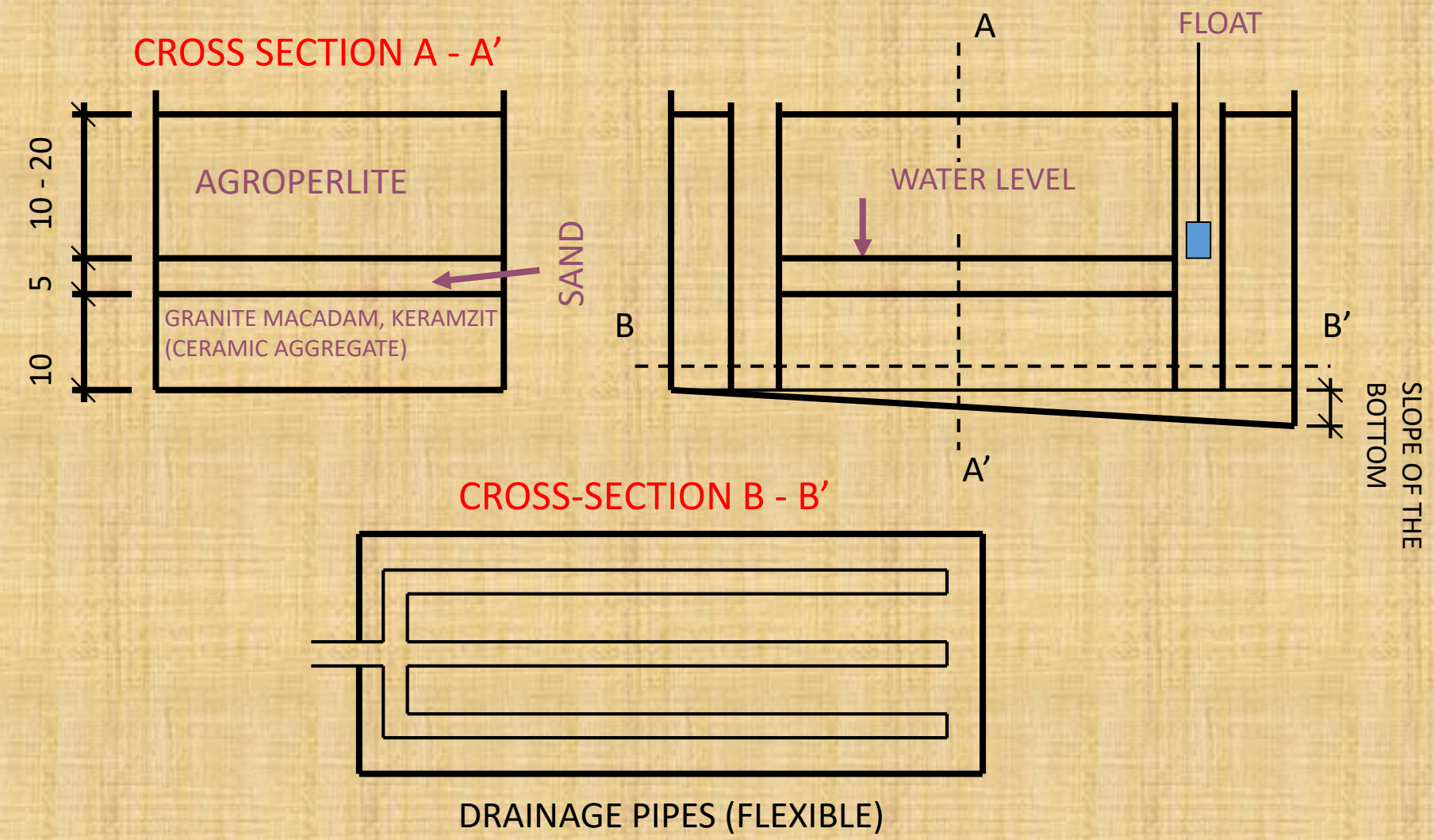


4. HYDROPONIC METHODS OF CULTIVATION OF PLANTING STOCK



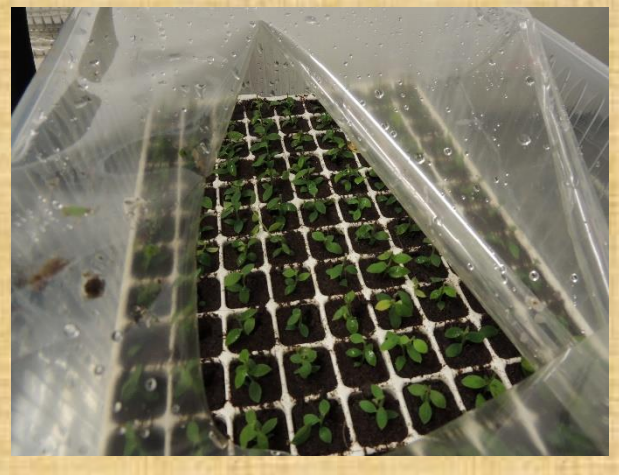
- **The plants are not cultivated in soil or organic substrate but in water with dissolved nutrients – the culture medium. However, the plants need to be naturally anchored. To do so, chemically inactive inorganic substrate is used – the carrier medium (gravel, sand, macadam, perlite, basalt wadding).**
- **The carrier medium is put in impermeable tubs, then the culture medium is added; the seed is sown onto the carrier medium. The root system penetrates through the carrier medium, trying to reach to the culture medium that rises to the tub surface. The resulting product is a bare-root seedling.**
- **The hydroponic method of cultivation always takes place in a greenhouse, where all factors are regulated like in the cultivation of bare-root seedlings in the organic substrate. The amount of the nutrients supplied is adjusted according to the development of the seedlings.**

HYDROPONICS SCHEME



5. IN VITRO TECHNOLOGY

- **The plants are cultivated in a fully controlled environment of a laboratory for the whole time – in aseptic conditions**
- **Biological principle - totipotency**
- **The so-called explantate develops a shoot, which then divides into other explantates**
- **When we have a sufficient amount of above-ground parts, the root system is grown (the composition of the culture medium is different)**
- **Acclimatization of the plants – transfer to autotrophic nutrition and a solution for the vitrification**
- **The plants are hardened off in a shade and at the holding area**
- **Planting**



PLANTING STOCK CULTIVATION FORMULA

- **The planting stock must be marked with a cultivation formula – the formula identifies its age and the technologies used for its cultivation (a combination of numbers, letters and graphic symbols)**
- **The sum shows the total age, the number after the letter or graphic sign shows the number of years of the cultivation by the given technology**
- **<u>Graphic symbols</u>**
  - **+ transplanting or replanting into a container**
  - **- root undercutting**
  - **f cultivation in artificial cover (glasshouse, greenhouse, hot bed)**
  - **k cultivation in a root impermeable container (containerized planting stock)**
  - **v containerized, cultivated by an air pruning**
  - **r plant cutting**
  - **t poplar plant cutting**
  - **s grafting (grafting or budding)**
  - **e explantate**

Example

Spruce f1 + v1 is a two-year containerized transplant; a one-year old bare-rooted seedling cultivated in an artificial cover was transplanted into a container in which the plant was growing on an air pruning for 1 year

Beech fk1 + 2 – 1 + k1 is a five-year old containerized sapling; one-year old containerized seedling cultivated in an artificial cover was transplanted into uncovered mineral soil, after two years the root system was undercut, after three years it was lifted and moved to a container, in which it was cultivated for 1 year

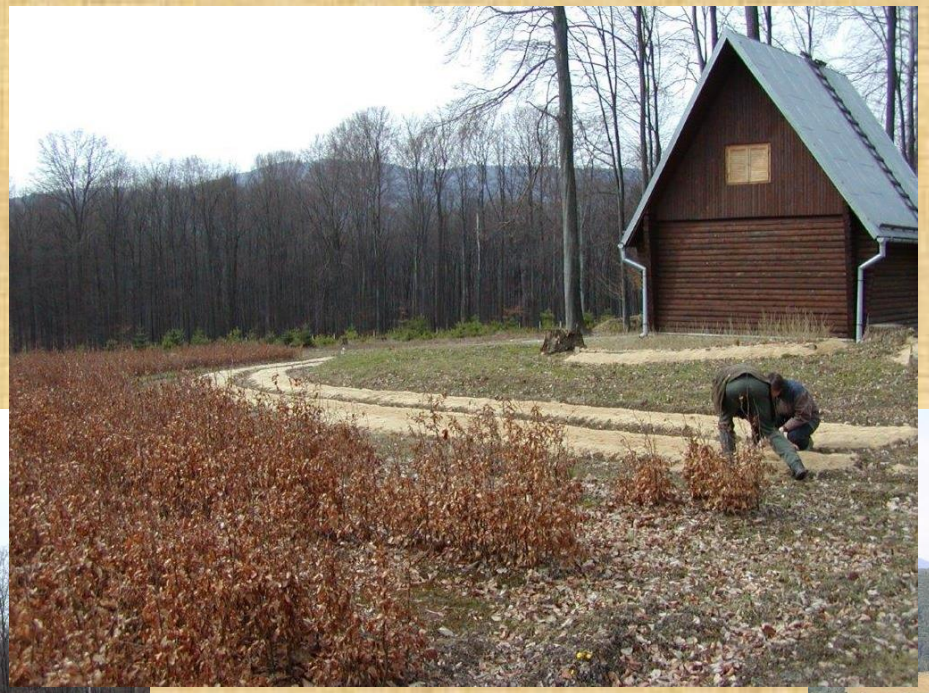
TYPES OF FOREST NURSERIES

Forest nursery is a piece of land designed for cultivation of planting stock. Standard nursery should be in optimal soil and climatic conditions.

- **permanent (production for many decades)**
- **temporary (production for max. 5 years – nutrient depletion, sudden and occasional need for planting stock, to prevent development of diseases)**

- **Seedling nursery vs. plant nursery**
  - **only production of seedlings x only production of transplants**
- **„Under-drip“ type of nursery**
  - **For production of planting stock with shade-loving tissue – underplanting**
    - **Under low stand density**
    - **Narrow (max. 1 stand height) stripe in the stand, east – west orientation**

- **Round type of nursery**
  - **To protect the planting stock from permanent sunshine**



- **Acclimatization type**
  - **For production of planting stock designed for high-elevation forest regeneration, at an altitude of over 900 m above sea level**

- **Special pollutant type**
  - **For production of planting stock for forest regeneration of air pollution localities**

The purpose of the acclimatization and the special pollutant nurseries is to prepare the planting stock for unfavourable conditions in their future localities – to concentrate the mortality into the nursery

- **Forest nursery using pollarded tree serving as a source of cuttings „Head type“**
  - **The poplar nursery, where cuttings are produced on the pollard tree („heads“)**

- **Transplant type of nursery - poplar**
  - **The poplar nursery where young plants are produced from cuttings**

- **Full-grown tree nursery**
  - **The nursery producing full-grown trees**

CALCULATION OF THE AREA OF NURSERY

production area - the area for cultivation of planting stock

- **net production area - production area minus paths**
- **the nursery area - fenced area**

- The calculation is made with perspective for approx. 20 years

1. **The proportion of artificial forest regeneration tasks for the given locality → area of regeneration in hectares minus the natural regeneration and the sowing**
2. **Depending on the condition in the particular locality: the objective of the forest planting, the maturity of the planting stock → the tree species, maturity, quantity**
3. **Determination of the cultivation technology, calculations → production area**

4. **Increasing the production area**

+ 20–25 % period of rest

+ mortality after planting

+ 20 % reserve

+ sale of planting stock

= total production area

5. **Increase by the paths, auxiliary areas etc.**

+ 5 to x %, depending on the size of the nursery

= total area of the nursery

Empirically = 1 per mille of the forest area (1 hectare/1000 hectares)

= 4 % of annual forest regeneration (hectare)

= according to the formula (e.g. Voče)

SOIL PROPERTIES

- **the main factor is the mechanical structure (and pH)**
  - **sowings up to 25 %, transplanting up to 30 % of clay particles**
- **light soil – sandy, sandy-loamy, loamy-sandy soil without skeleton**
- **topsoil layer 35 cm (large-sized plants 40 cm, saplings 60 cm)**
- **ground water at least 70–100 cm deep**
- **suitable pH – up to 6.0**
- **humus 3–10 %, can be treated**
- **P_2O_5 – 250 mg.kg^{-1}, K_2O – 160 mg.kg^{-1},**

  can be treated (single-type fertilisation is not recommended)

CONFIGURATION OF THE TERRAIN

- **sowing part: slope up to 1 %, other parts up to 3.5 %**
- **max. slope 5 % (acclimatization nurseries)**
- **exposure - up to 450 m NE, NW**

  - above 450 m SE, SW
- **eliminate extreme localities (frost, wind, floods!)**
  - **protection function of surrounding stands**
  - **protective strips of trees, artificial barriers**

SOURCE OF WATER

- **not contaminated (salinity, pH, portion of clay particles, toxicity)**
- **hardness up to 10°**
- **preferably: natural - gravitation**
  - **max. 500 m far from the nursery**
  - **elevation difference max. 10 m**
- **irrigation dose**
  - **free area 20–30 $m^3.day^{-1}.ha^{-1}$**
  - **intensive methods (greenhouses etc.) 40–50 $m^3.day^{-1}.ha^{-1}$**
  - **holding area 70–80 $m^3.day^{-1}.ha^{-1}$**
  - **purpose irrigation +30 %**
- **reserve for 4 days of irrigation doses**

! approx. 150–200 $m^3.ha^{-1}$!

SURFACE AREA AND SHAPE OF NURSERY

- **homogeneous soil conditions!**
- **rectangular max. 400 x 100 m, ideally 200 x 60 m**
  - **orientation : east – west; in slope along the contour line**
- **headland 5–8 m**
- **protective stand strip 30–40 m**
  - **modification, regeneration**
  - **also negative effect (competing roots, weed, shadow, pests)**
- **distance of work sections within the set max. 500 m**
- **min. surface area of one nursery 4 ha**
- **hardened (metalled) main roads**

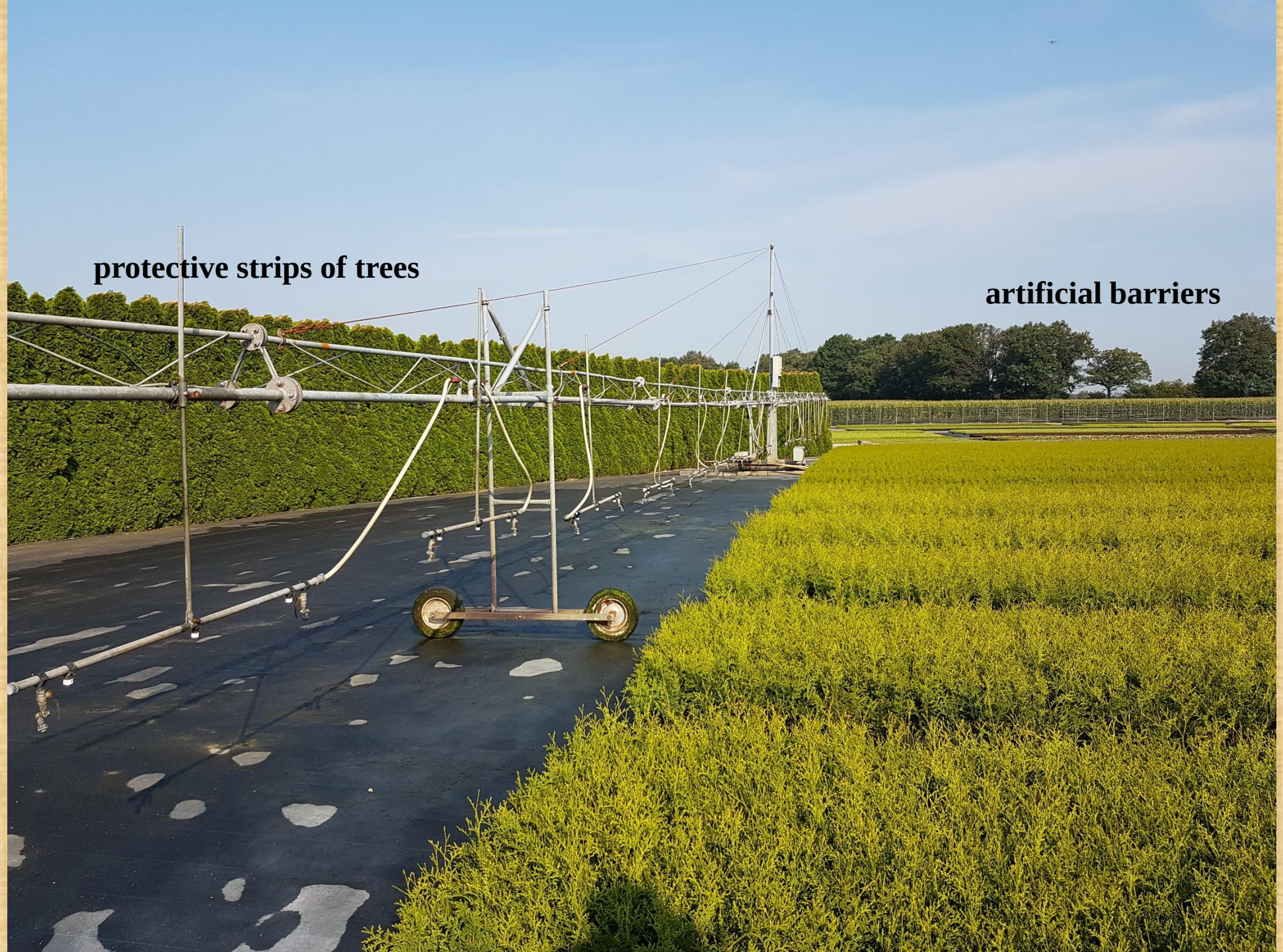

52
41
43
42
53
44
51
50
45
48
47
49


Mazánkova
Hájenka
střelnice

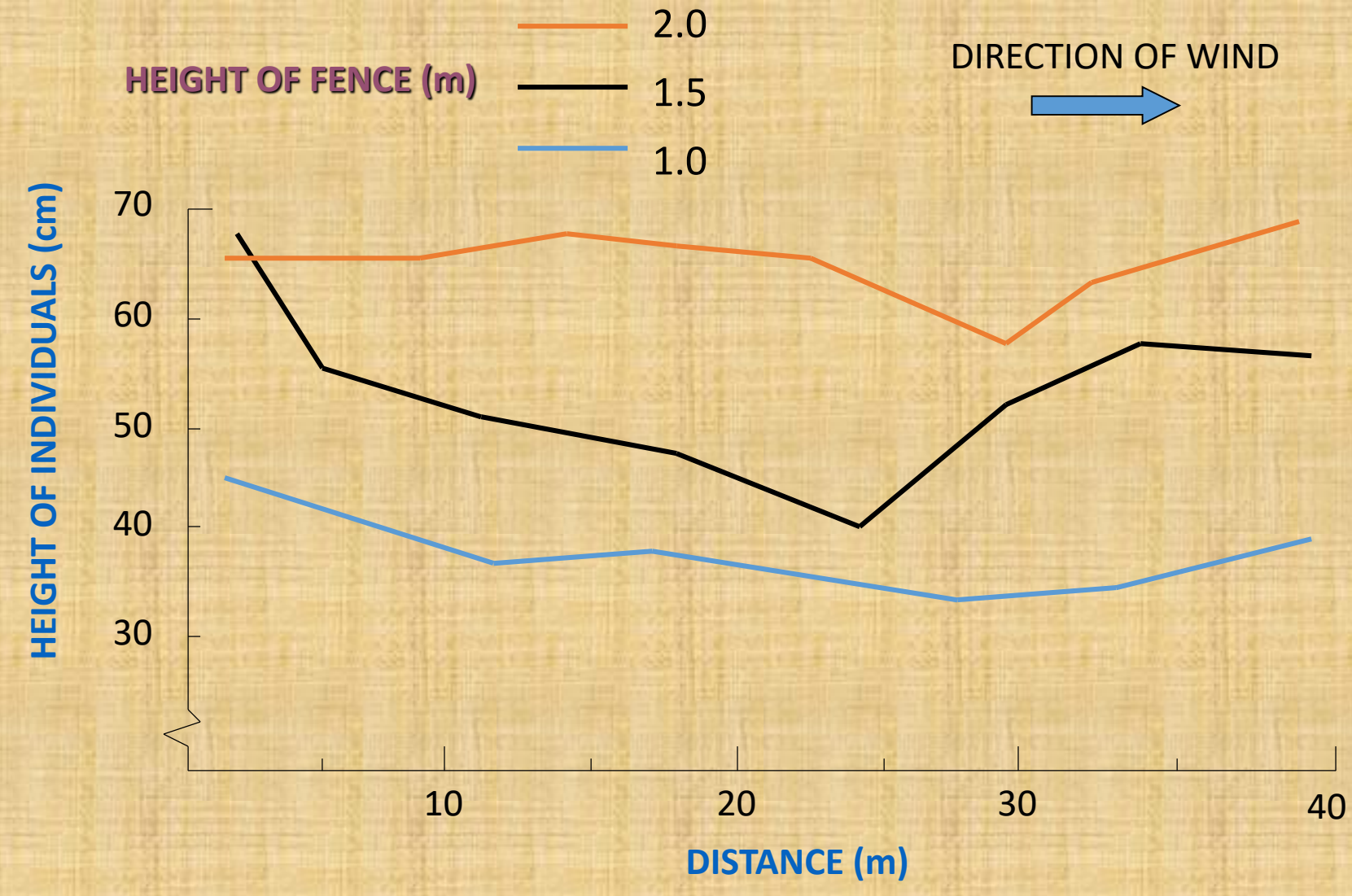

artificial barriers


protective strips of trees


protective strips of trees


protective strips of trees
artificial barriers

HEIGHT *Fagus sylvatica* 1-1 DEPENDING ON THE FENCE HEIGHT (WIDTH OF PROTECTIVE STRIP 40 m, open nursery)



ACCESS BY ROAD

- heavy vehicles at any time

ELECTRIC CONNECTION

- depending on the project – min. 80 KW

TELEPHONE – INTERNET

WORKERS

- top nurseries: 0.6 workers.hectare^{-1}.year^{-1}
    - much more during the season
- their transport?
- all-year employment?, meals?
- hygienic background: absolutely necessary
- continuous re-training
- special attention to drivers and specialised work stations
- specialist for protection and nutrition

ECOLOGIC CRITERIA – none of the nurseries is suitable for cultivation of all tree species!

NURSERY EQUIPMENT

WORKING AND SANITARY BACKGROUND (BUILDINGS)

- **in small nurseries: cabins and shelters**
- **in large nurseries – offices, cloak-rooms, bath-rooms, toilets, canteen, flats**
  – garages, work-rooms, storage houses etc.
  – handling halls

STORAGE HOUSES FOR PLANTING STOCK

- **air-conditioned, cooling boxes, cellars, snow caches (pits)**

STRATIFICATION CELLARS

ARTIFICIAL COVERS AND SHELTERS (greenhouses, glasshouses, hot beds)

SHIELDS (shading of plants)

IRRIGATIO SYSTEM

COMPOSTING PLACE

HOLDING AREA

MACHINES AND EQUIPMENT

- **for complex equipment located on 100 ha large forest nursery: 80 mechanization devices**

<u>LABORATORIES</u> (quality of the substrate, seed lot, planting stock)

<u>SEED STORAGE ROOMS</u>

<u>METEO STATION</u>

Machines and equipment depend on the size of the nursery and operations intensity.

<u>Minimum requirements</u>:

- **source of water and the water distribution system**
- **hygienic background facilities**
- **tool storage**
- **snow pit (to put and store the planting stock)**

ESTABLISHING FOREST NURSERIES ON FOREST LAND

- **cutting down trees, removal of stumps, brushing roots out**
  - **more than the area of the nursery – competition, shadowing**
- **drainage – open trenches max. 80 cm**
- **uneven terrain - removal of topsoil (approx. 40 cm)**

  - terrain adjustment, levelling

  - spreading the topsoil and mixing it with the subsurface
- **ploughing to the depth of 45 cm**
- **in the autumn: deep ploughing**
- **next spring: - normal nursery production**

  - preferably: transplanting or green fertilization
- **before ploughing: fertilization and melioration (aeration etc.)**

ESTABLISHING FOREST NURSERIES ON OTHER THAN FOREST LAND

- usually no need to level the terrain (plane)
- problems: weed, without mycorrhiza, high pH, toxicity, open areas, compacted subsoil
- eliminate areas with pH above 6, phytotoxicity above 50 %
- weed
  - stubble ploughed under
  - chemical intervention
  - growing root-crops (the best way)
  - fallow
- mycorrhization (at least with planting stock)
- aeration to 80 cm
- after that: the same procedures as in forest land, constructing barriers

THE PRODUCTION IN NEW NURSERIES IS VERY HIGH

IT IS NECESSARY TO FERTILIZE AFTER 4-5 YEARS!

FOREST NURSERY FENCING

- min. height 170 cm (red deer: min. 220 cm)
- concrete posts, distance 4–5 m
- gate, small gate on each side
- rabbits – mesh fencing, mesh size up to 4 cm, 25 cm into the earth
- black (wild boar) – concrete feet elements
  – ropes attached in the ground

NURSERY LAYOUT

- boards (there are no paths, tractors enter anywhere - large sized plants, saplings)
- patches (paths - beds width 100 or 146 cm - transplants, seedlings)
- terraces (only in mountains)

NURSERY OPERATION PRINCIPLES

1. Individual tree species (and of the same age) should be grown separately, in one part of the nursery
2. The planting stock of the same age should be cultivated in the direction of use of mechanization devices
3. Tree species should be alternated throughout the area
4. Melioration measures (green fertilization, fallow) once in 4–5 years (as the latest)

Treatment of the area to establish a nursery – stumping

Treatment of the area to establish a nursery – brushing roots out

Treatment of the area to establish a nursery – ploughing to 45 cm

Treatment of the area to establish a nursery – surface levelling

Nursery administrative building

Nursery administrative building

Electric connection, internet

Background facilities for employees

Climatic station

Fencing

Machinery storage

Machinery storage

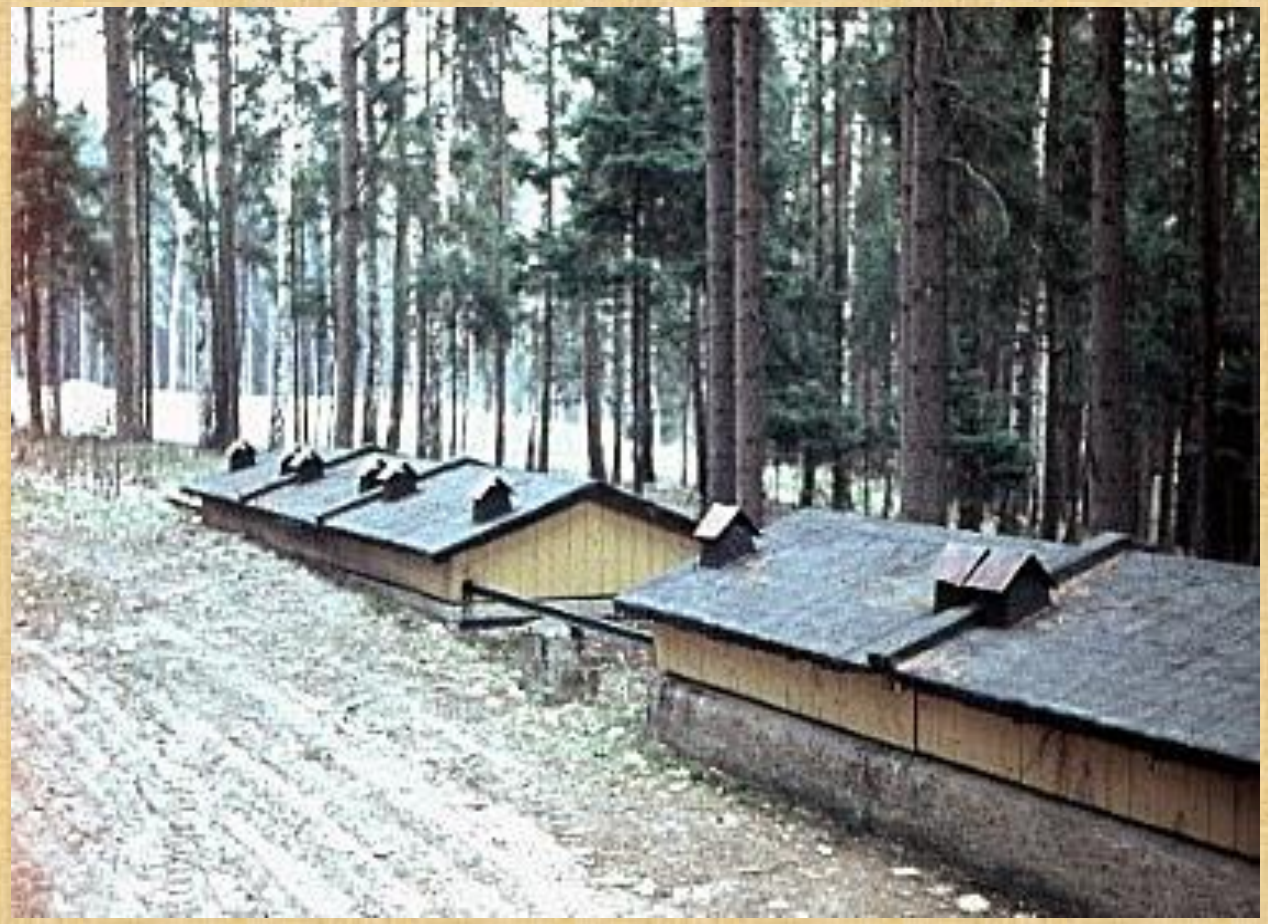
Machinery storage

Fuel reserve

Handling hall

Handling hall

Snow pit



Germination tables

Storage of seeds

Cold store - beechnut storage


Work-room

Marking work boards

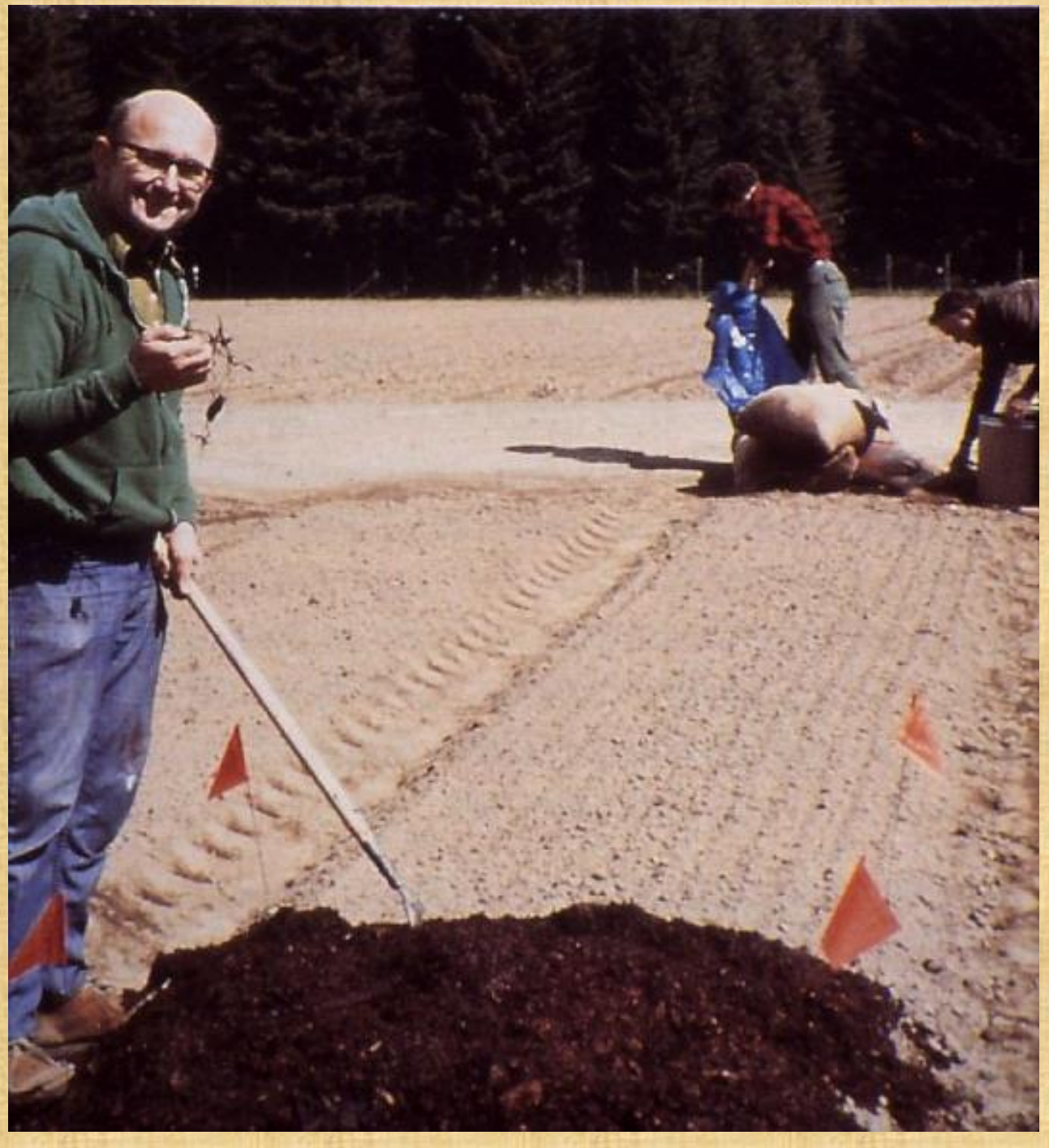
Marking beds

Large work board

Work board of optimal size

Work board after soil treatment

Inoculation of soil with leaf litter (mycorrhiza)

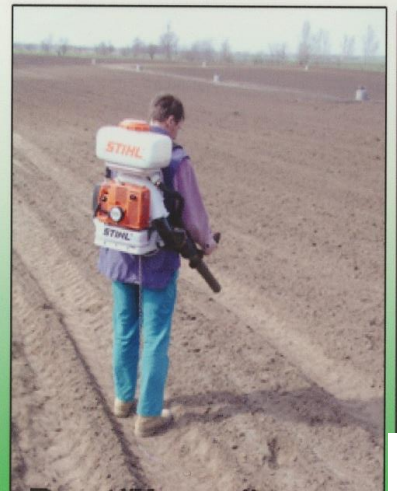


Inoculation of soil and roots with planting stock (mycorrhiza)

by plant soaking

manually

use of mechanization when producing containerized planting stock



with a sprayer device

manually in the greenhouse

in rows, using a tractor with a sowing device

Thank you for your attention