Advance in seedling management

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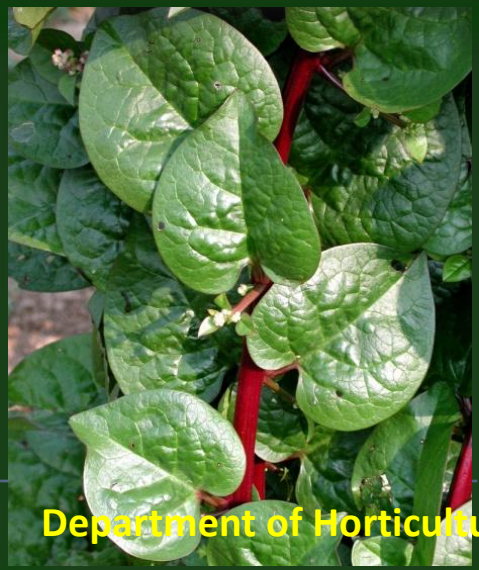
The meaning of seedling

- A young plant sporophyte developing out of a plant embryo from a seed.
- Seedling development starts with germination of the seed.
- A transplant

Growing vegetable >> Asexual propagation



Growing vegetable >> Sexual propagation

Direct seed

Transplanting

How to grow vegetables from seeds

- Direct seeding
- Transplanting
  - Outdoor seedbed
  - Cell tray/Container

1. Direct seeding

- Direct field seeding
  - Planting time
  - Low cost seed (OP)
  - Proper depth
  - Rate of sowing
  - After planting care
  - Losses of seeds and young plants
  - Low cost and labor requirement

How to ??

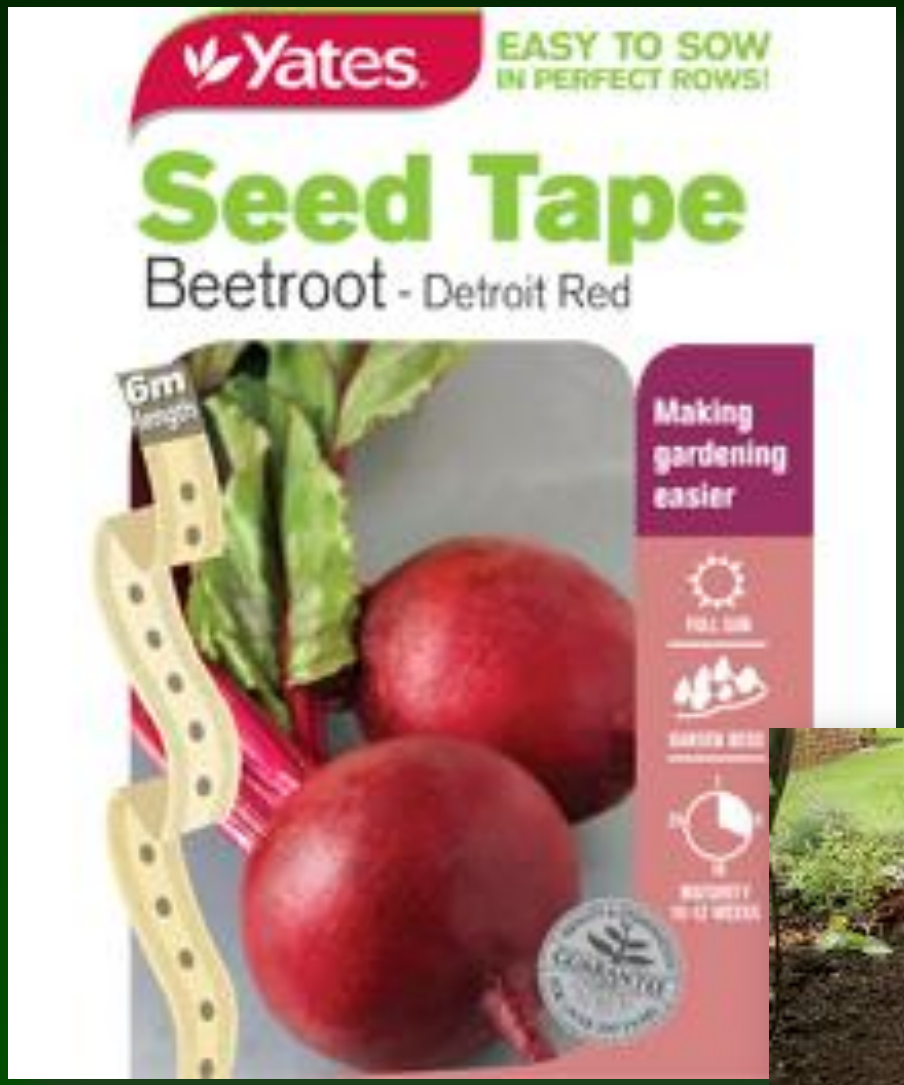
- Broad casting by hand or special planters or seeders
- Coated with a bird or rodent repellent
- Species
  - Chinese kale, Celery, Lettuce
  - Water spinach/kangkong
  - Brassica crops

Direct seeding/broadcasting

Vegetable seed planter

Cabbage planter

Pumpkin planter


Yates
EASY TO SOW
IN PERFECT ROWS!
Seed Tape
Beetroot - Detroit Red
6m
Making gardening easier


Poppies
oriental silk poppies
(orange, scarlet, and pink)
Seed Tape
Instructions inside
Baby's Breath
Basil
Seed Tape
Italian Large Leaf, Purple Opal
Siam Queen Thai
Instructions inside

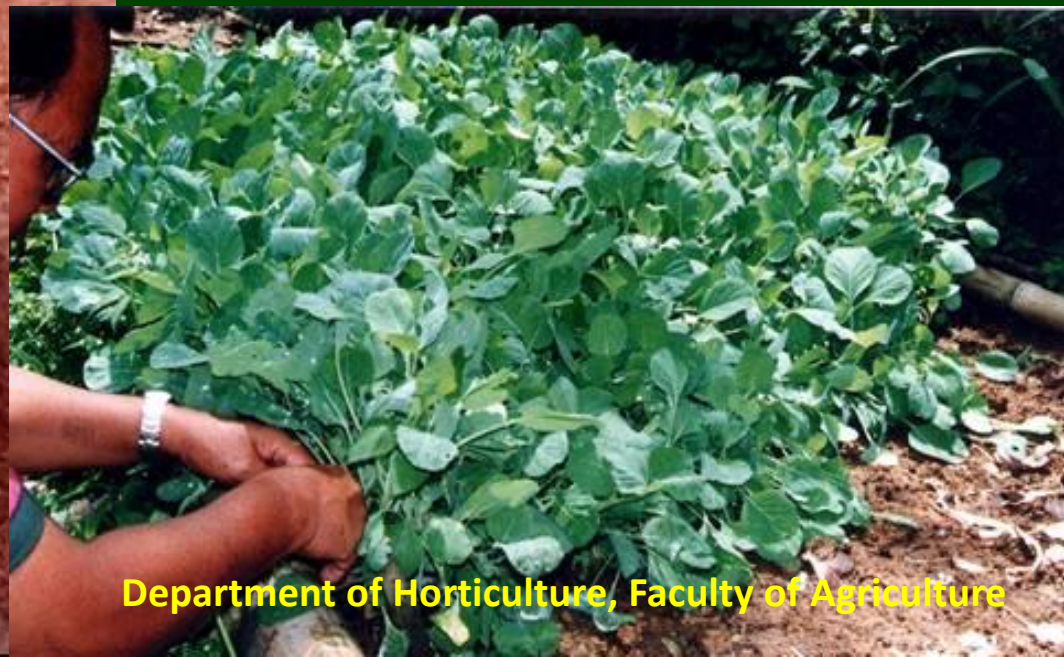
2. Outdoor seedbed

- Site selection (soil fertility, no flooded)
- Seedbed preparation
- Determine seeding rates
- Sowing seeds and transplanting into field or greenhouse

Outdoor seedbed

Tomato

Cabbage



Outdoor seedbed

3. Cell tray/Container

- Sowing seeds in cell tray/container and transplanting into field or greenhouse
- Expensive seeds (hybrids)
- Intensive care is needed

Sowing container

Seedling management

Direct seeding

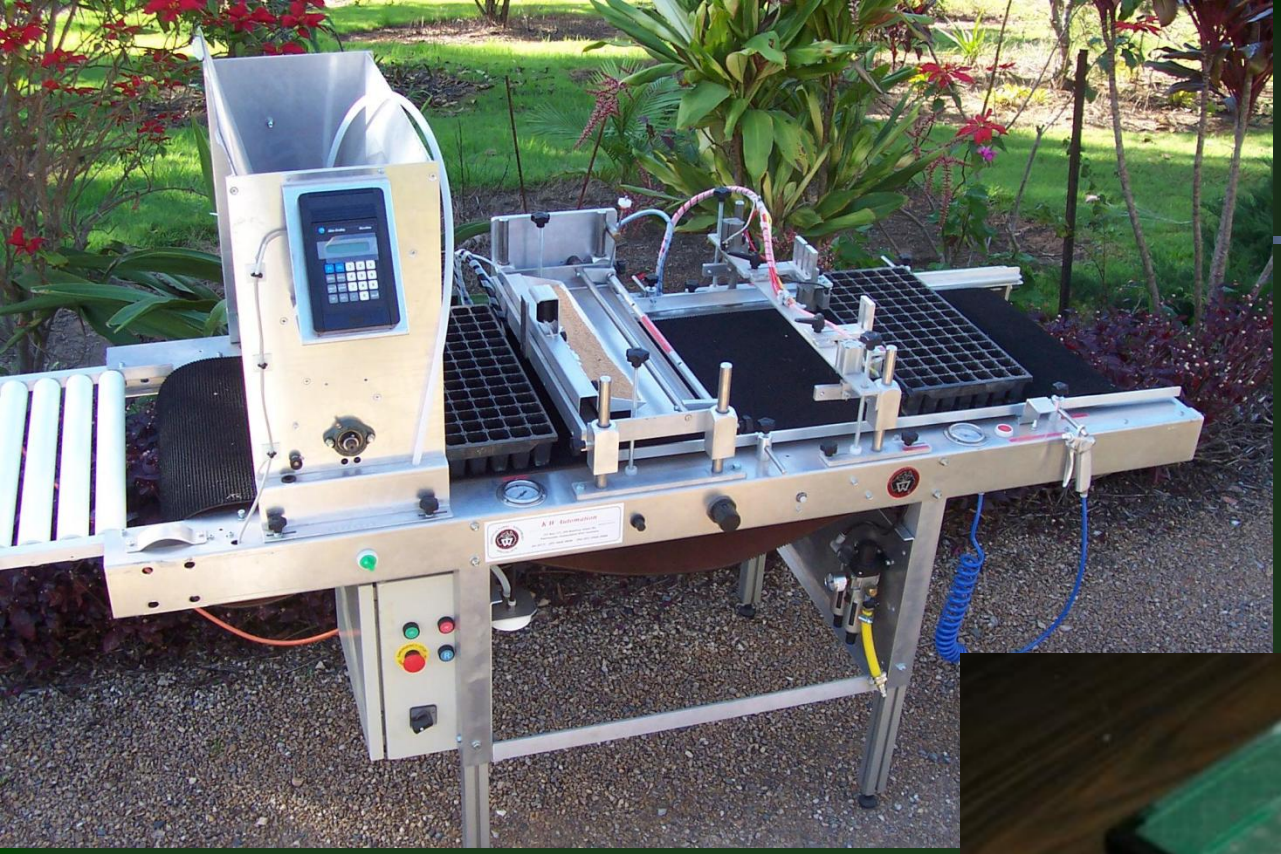
Outdoor seedbed

Transplanting

Transplant production

Commercial transplant production

Media filling machine



Vacuum seeder

Pepper transplant production I

Pepper transplant production II

Characteristics of a quality transplant

- Proper height; short internodes and lateral branching
- Solid green leaf color
- Sufficient leaf expansion with proper number of leaves
- No buds or flowers evident
- Active, healthy root system with root hair
- No disease or insect

How to get a high quality transplant

Seeds	• OP/F1 hybrids • Coated/Pelleted seeds
Growing media	• Peat moss/Coir dust • Vermiculite/Rock wool
Container size and shape	• Cell tray/Pot
Environmental conditions	• Light/Temperature • Moisture/Nutrients

1. Seed

- Avoiding using unknown-source seeds
- Avoiding using carry-over seed or unsaved seed
- Well-known seed companies
- Buy seed in amount you needed at a time

Coated seed **Pelleted seed**

+ chemicals + hormone + etc.

Uniformity/High germination/High vigor

2. Growing media

- Pure soil is not desirable because it may crust or poorly drainage
- Mixed, compost, peat moss, coir dust etc. are desirable
- Should provide good drainage but retain moisture well enough
- Free from pests and contaminating chemicals

Functions of growing media

- Provide a suitable anchorage for the root
- Act as a reservoir for water and nutrients
- Act as a buffer against sudden changes in the environment
- Permit gas exchange to and from the roots

Types of growing media

- Organic materials
  - Peat moss, bark, wood chips, coir dust, rice hull, carbonized rice hull, etc.
- Inorganic materials
  - Sand, perlite, vermiculite , rock wool

Media components

Vermiculite

Rock wool

Compost

Rice hull charcoal

Perlite

Coir dust

Properties of growing media

1. Physical properties
   - Total porosity = water holding capacity + Air porosity
   - Bulk density = weight per unit volume
2. Chemical properties
   - pH : availability of nutrient ions (5.0-6.5)
   - Soluble salts : salts that is soluble in water

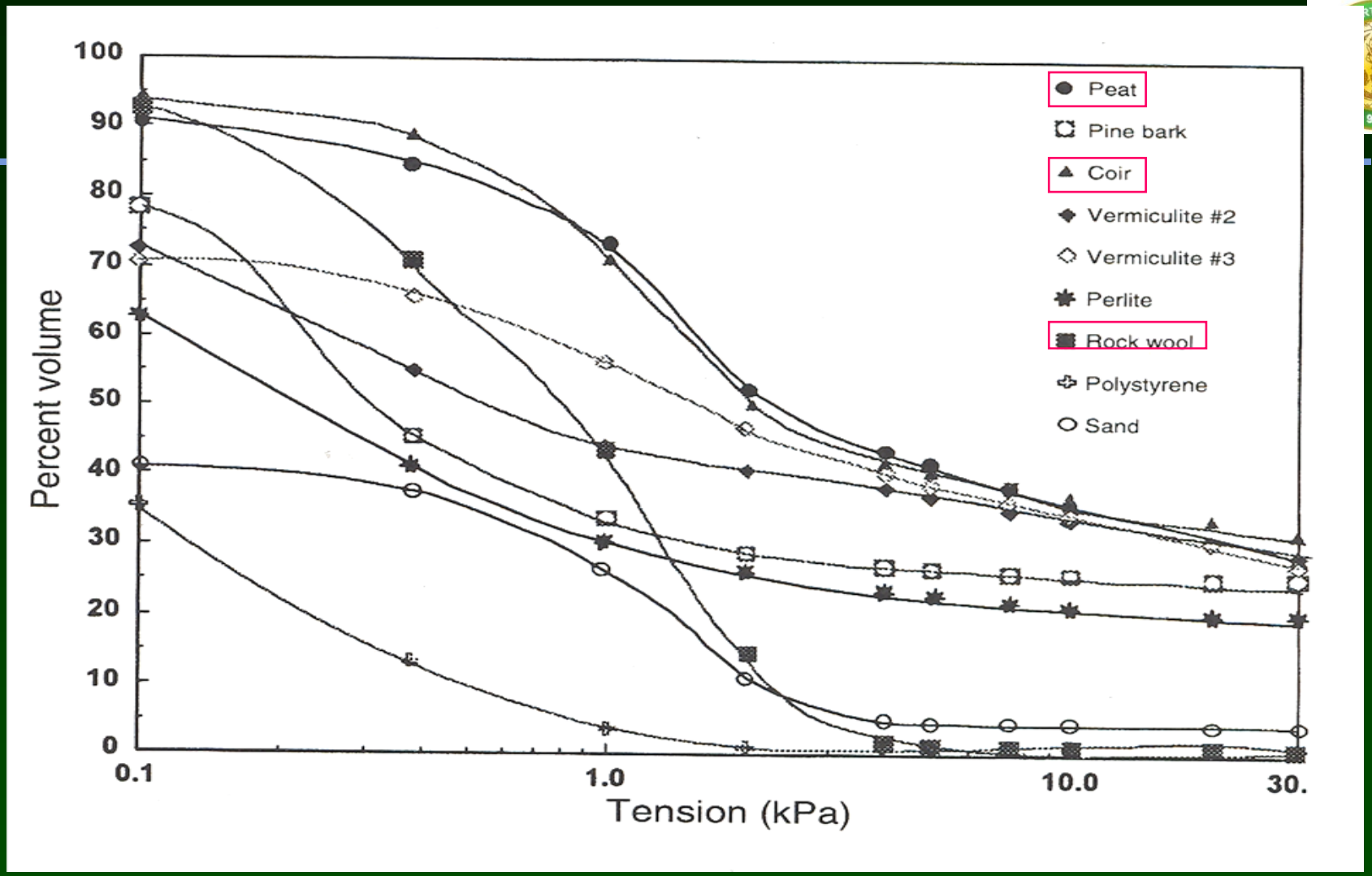
Physical properties of various media

Media	Total porosity (%vol)	Air porosity (%vol)	Bulk density (g/cc)	Moisture content (%)
Coir fiber	92-94	9-12	0.07-0.08	70-80
Peat : Vermiculite (1:1)	88	9-10	0.14	70
Peat : Perlite (1:1)	78	15-18	0.12	60-70
Peat	89-94	12-20	0.06-0.1	75-80
Perlite	68	28-32	0.15-0.17	50
Vermiculite	78-80	6-10	0.16-0.18	60-65

The chemical properties of growing media

Substrates	CEC me 100 g^{-1}	pH H_2O	EC dS m^{-1}
1. PM :RH	67.0	5.6	0.37
2. PM : PHC	85.8	5.7	0.88
3. CC : RH	68.6	5.7	1.10
4. CC : PHC	69.0	6.4	1.91
5. RHC : RH	38.2	5.8	0.67
6. RHC : PHC	38.4	7.5	1.19

Chulaka et al., 2003



Moisture retention curves of growing media

Peat moss

- Peat moss is a natural product formed by the partial decomposition of mosses and sedges
- Peat is a popular component for growing media

The advantages

- Good structure and texture, which encourages root development.
- Good water holding capacity without getting too waterlogged

- Good chemical properties making fertilizer application easy.
- No minerals that will lock up nutrients, so fertilizer rates can be low.
- It is more or less sterile, so there is little risk of soil-borne plant diseases.
- It is lightweight, so plant displays are easy to transport and move once in situ.

- Natural product so very little product processing is required.
- The use of peat by gardeners and horticulturists is damaging the environment.

BEFORE AFTER

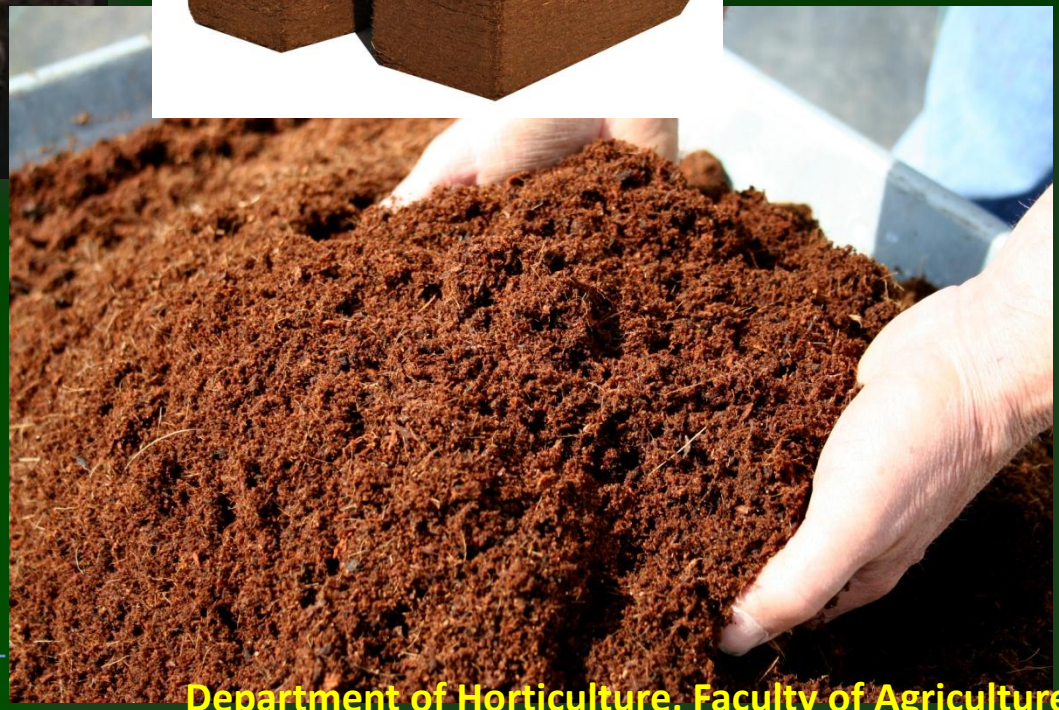
Coconut coir/Coir dust

- a byproduct of the coconut industry
- made form the ground husks and fibrous shells of coconuts
- Good structure and texture
- Little risk of soil-borne plant diseases
- Variable quality and consistency of product
  - because it has often been left exposed to the elements before being processed

Physical properties of coir dust from different sources

Sources	Bulk Density (g cm^{-3})	Air-filled pore space (v/v%)	Water filled space (v/v%)	Total pore space (v/v%)	Total solid (v/v%)	Water holding capacity (w/w%)
Mindanoa1	0.05	11.5	74.9	86.4	13.6	910
Mindanoa2	0.08	9.5	80.0	89.5	10.5	1100
Luzon 1	0.06	11.0	75.7	86.7	13.3	900
Luzon 2	0.04	12.5	73.0	85.5	14.5	750
Luzon 3	0.06	11.5	76.3	97.8	12.2	950
P>F	**	*	*	*	*	*
LSD(0.05)	0.02	2.0	6.4	3.5	3.0	125

Cocopeat = coir dust + + +

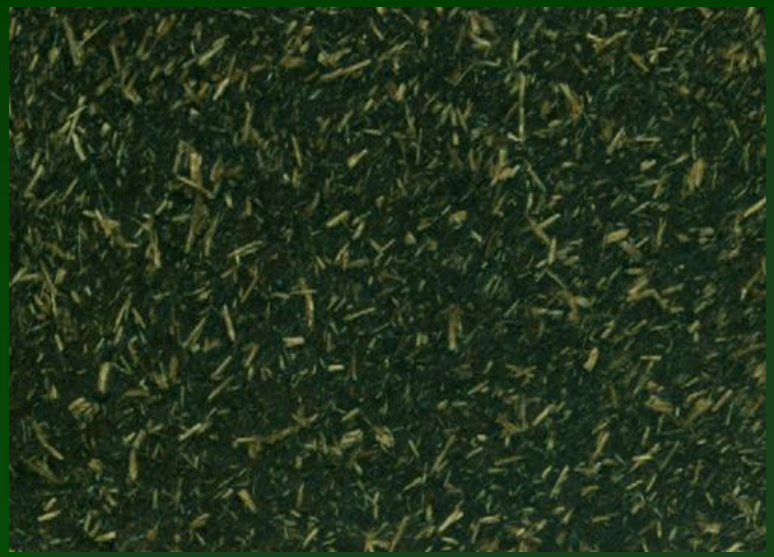


Rice Hull

- light in weight
- increase drainage or aeration.
- be slightly acid (pH = 5.7 to 6.2)
- N should be included to avoid deficiency problems.
- composted rice hulls will hold more water than unprocessed hulls
- unprocessed or composted rice hulls : high Mn

Bagasse

- a fibrous byproduct of the sugarcane industry.
- provide additional open pore space in a mix
- tends to break down rapidly with the addition of fertilizer and water



Animal Manure

- High salts
- Fine particle size and weed seeds
- Retain nutrient contribution
- Be able to improve media physical properties

Inorganic components

1. **Perlite**
   - most commonly used
   - mix to improve the drainage or increase the percent aeration.
   - lightweight (6 to 8 lb/ ft^3), chemically inert, pH neutral, sterile and odorless.

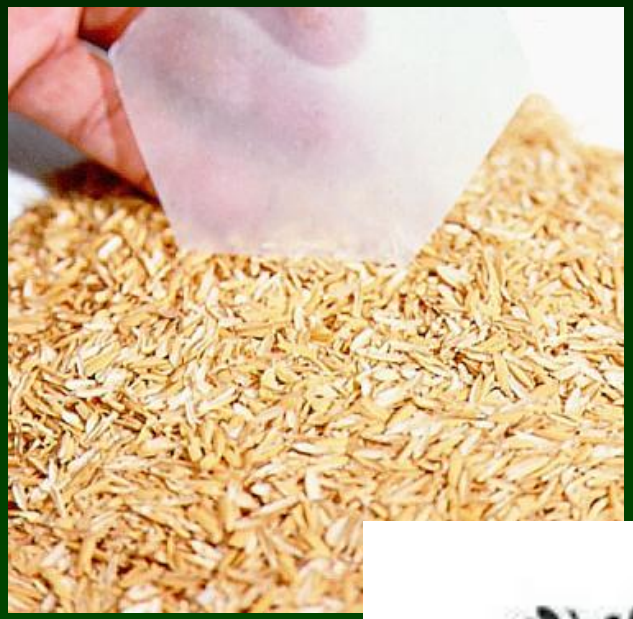
2. Vermiculite

- originate as mined minerals
- its plate-like structure holds large quantities of water
- hold positive charged nutrients like K, Mn and Ca
- sterile and light in weight (5 to 8 lbs/ft3).
- pH will vary depending on where it is mined

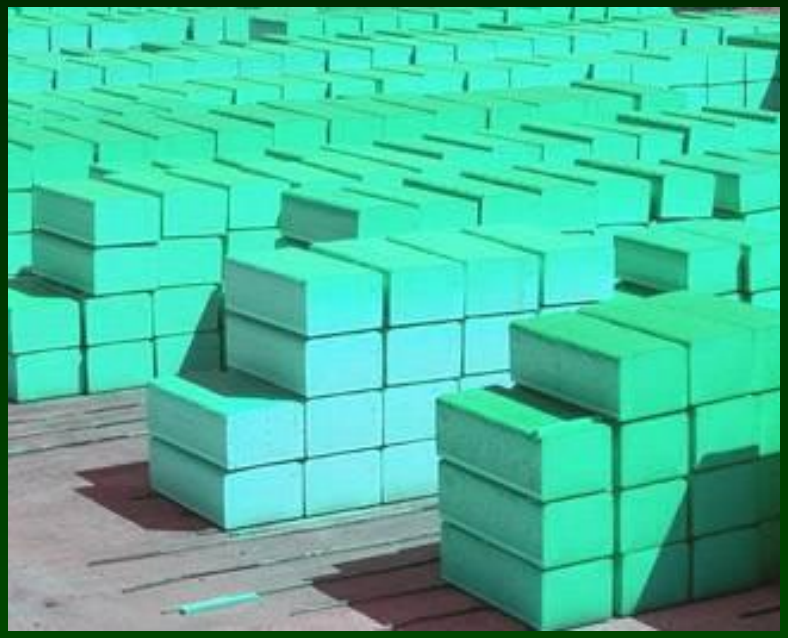
3. Sand/gravel

- improve drainage
- a wide range in particle sizes, generally use medium to coarse sands (0.25 to 2 mm)
- High bulk density

Other materials



Synthetic materials ; plastic



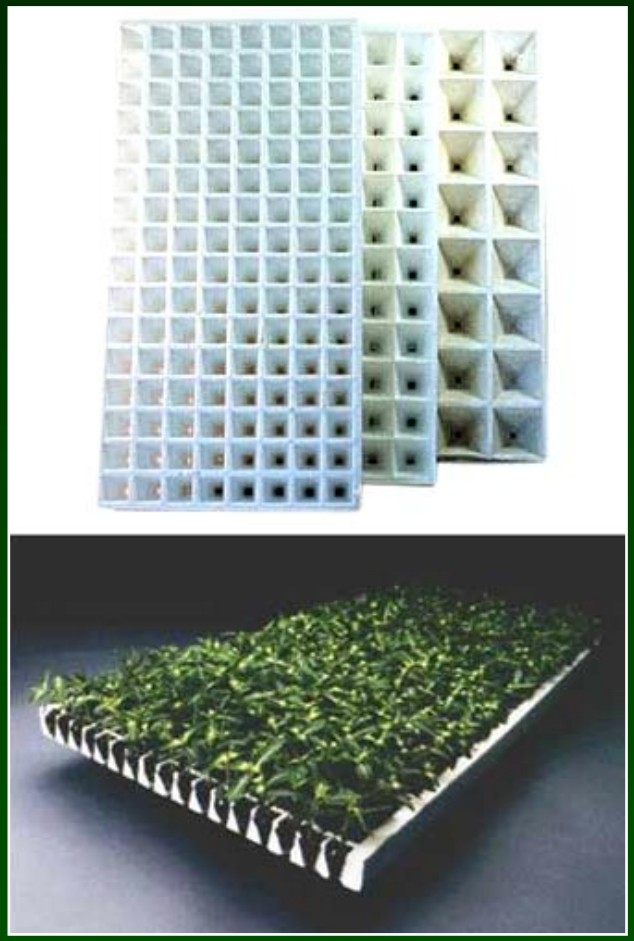
Media handling

- Compaction
  - The media should not be packed down
  - The tray should not be stacked directly on one another
  - Compression decreases air porosity
- Peat mix
  - Adding some moisture before filling trays improve AP-WHC ratio

- Each component is different properties
- Good media must be able to hold water but still have enough air porosity
- Air porosity less than 2%
  - will hold too much water
  - Not allow sufficient root development

- Create a depression in the plug cell without compression
- Some crops need more depression in the plug cells for the seed to fit and still be covered
- Avoid compaction of the media by cross-stacking filled trays

3. Container size and shape



Seed trays

- Cell tray/Plug cell etc.
- A sufficiently thick quality to keep their shape when picked up
- Single seedling

Different sizes of cell tray

58-cell tray

98-cell tray

Disposable pots

- Are usually made of some form of processed organic material.
- Can leave a plant's roots undisturbed when transplanting
- BUT .. expensive

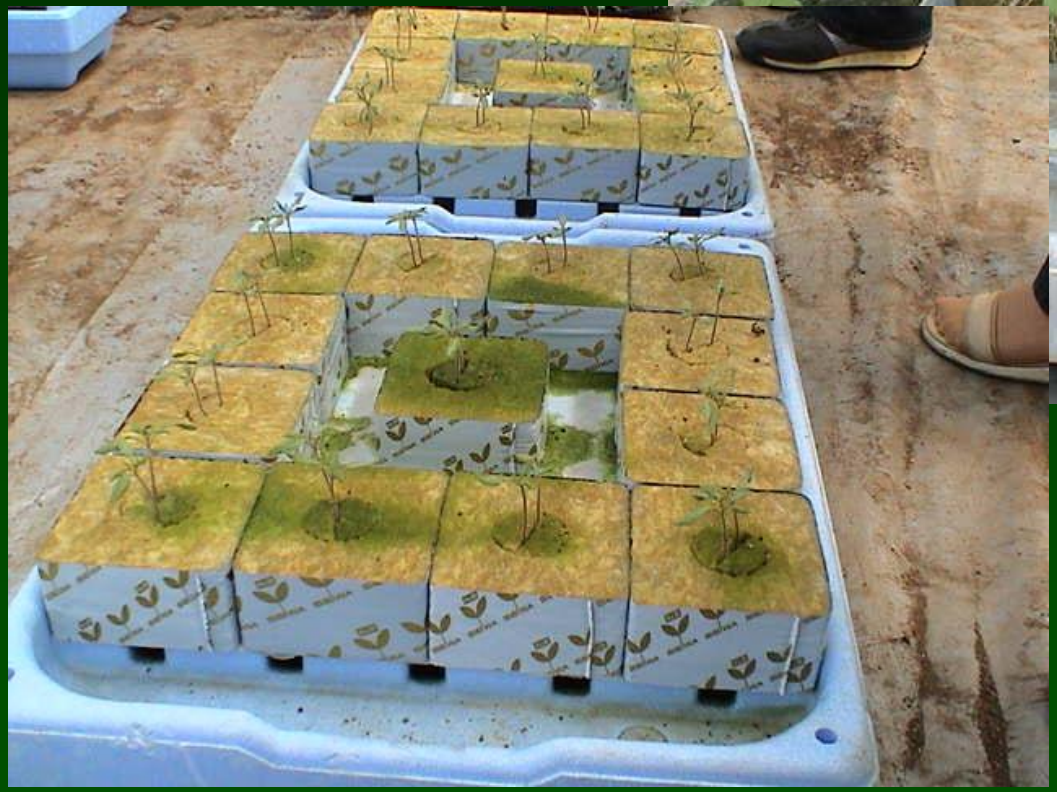
Soil blocks

- An alternative to pot
- Insert a seed or cutting and cover with compost
- Very effective and reduce the ultimate root disturbance

Rock wool

- originates from a natural mineral (alumino silicates with some Ca and Mg) that is heated and then spun into fibers
- are used to make blocks or cubes as a finished product.
- Blocks or slabs of rock wool are used by hydroponic growers

Rock wool



Effect of container size on root form and plant growth

- Depth :
  - Decrease ➢ air porosity decreases
  - Lack of oxygen ➢ reduce growth rate
- Width
  - Wide container ➢ tip over than narrow container
  - Pot should be deeper than they are wide.

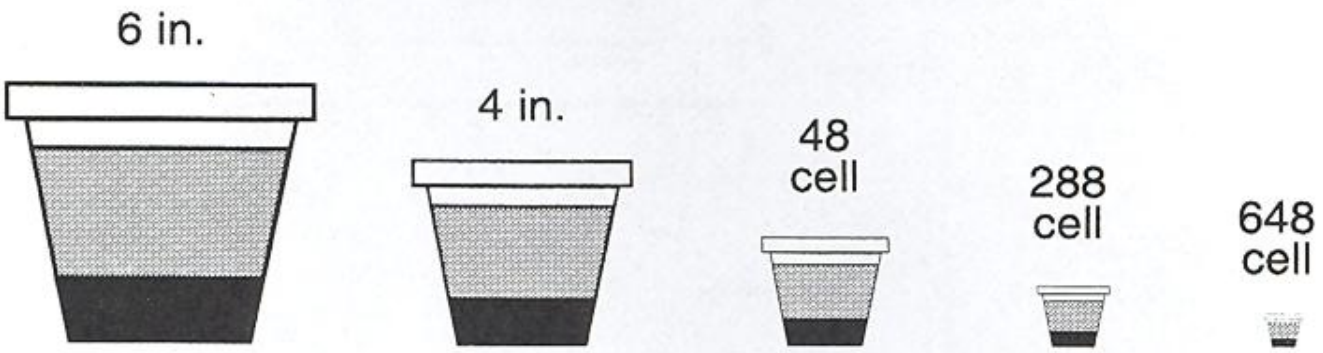
Advantages of using container/cell tray

- Less time and labor to transplant
- Faster and more uniform growth after transplanting
- Reduced loss to root rot after transplanting
- Earlier and more uniform flowering and yields
- Better use of seed and space
- Mechanization and labor reduction due to handling ease
- Can be held for delayed transplanting
- Less chance for disease to spread

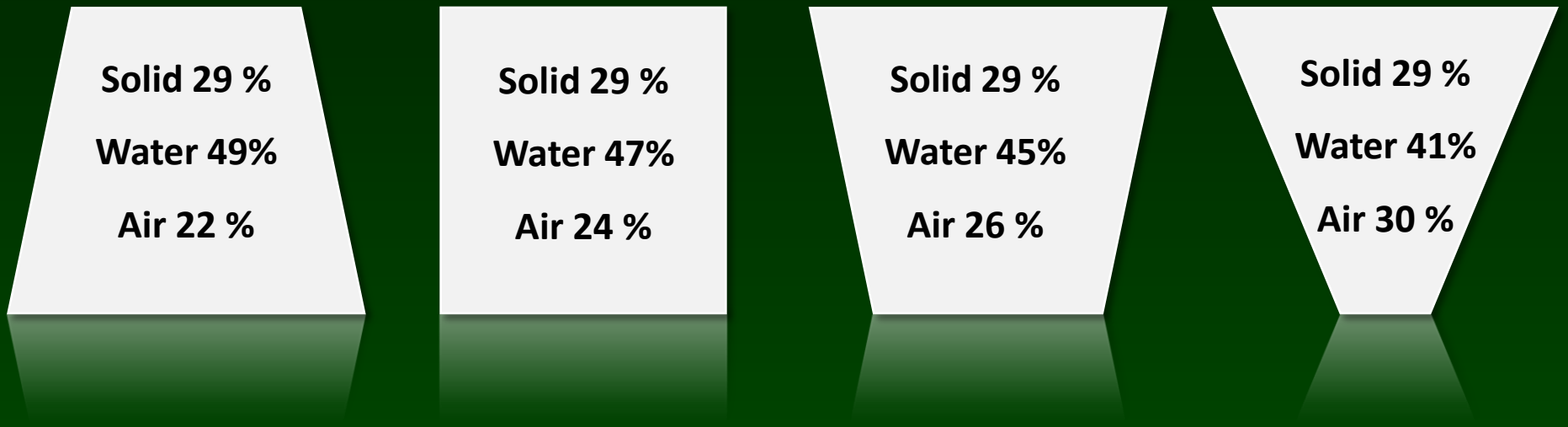
Disadvantages of using container/cell tray

- Grower required to change production method
- More difficult to produce plugs yourself, as opposed to buying them in
- High initial costs for equipment and greenhouse space
- Specially trained people needed to seed and grow the plugs
- Specialized techniques needed for growing plugs
- Greater cost per seedling for plugs

Effect of container size on air-water relations of peat:vermiculite (1:1) media



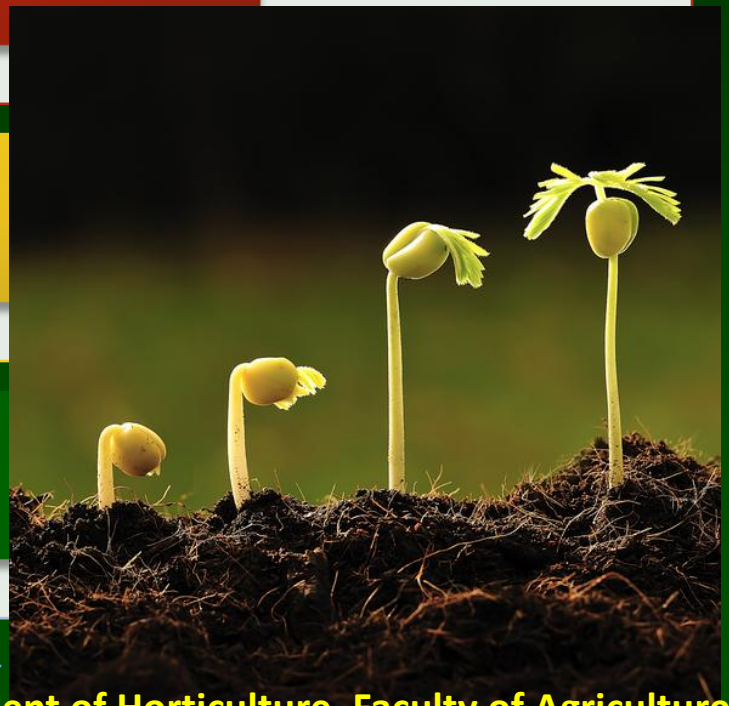
	6 in.	4 in.	48 cell	288 cell	648 cell
Air (%)	20	13	8	3	0.5
Water (%)	67	74	79	84	86.5
Solid (%)	13	13	13	13	13



Containers of the same height have increasing AIR and decreasing water contents as they taper more sharply at their bases

4. Environmental conditions

- 4.1 Light
- 4.2 Temperature
- 4.3 Moisture
- 4.4 Nutrients



Stage of transplant growth

Stage 1 Primary root emerges from seed

Stage 2 Radicle penetrate the soil, stem and cotyledon emerge

Stage 3 True leaves grow and develop

Stage 4 Seedlings are ready

Stage of transplant growth

Stage 1

- Primary root emerges from seed
- Growth requires high levels of moisture and oxygen around the seed

Stage 2

- The root (radicle) penetrate the soil, stem and cotyledon emerge
- The amount of oxygen increases, moisture applied should be decreased

Stage 3

- True leaves grow and develop
- Require sufficient nutrition and more light

Stage 4

- Seedlings are ready for shipping, transplanting or holding
- Require sufficient nutrition and more light

Factor affecting during stage 1 to 4

Condition	Stage 1	⇨	Stage 4
Temperature	High	⇨	Low
Moisture	High	⇨	Low
Light	Low	⇨	High
Nutrition	Low	⇨	High

Fertilizing based on environment

Temperature

- Low root zone temperature ➡ slow down growth,
  - NH_4 accumulation ➡ toxicity
- High root zone temperature
  - NH_4 will be used quickly
  - Stretched and soft shoot growth

Light

- Low light,
  - Root growth < shoot growth
  - Fertilizer should be low NH_4 but high NO_3
- High light, PS higher ➤ need more food
  - Higher NH_4 to support maximum growth

Humidity

- High RH
  - Lower transpiration
  - Low Ca uptake, K continue
    - imbalance C : K
    - stretch seedling, thin leaf
- Low RH
  - Higher transpiration
  - High Ca uptake ➤ shorter shoot growth, shoot : root balance
  - Need more NH4

Moisture

- More frequency of irrigation ➤ lost fertilizer
  - more fertilizing
  - spindly seedlings
  - High NH4 and more Ca
- Less frequency of irrigation
  - Control seedling height
  - Well root development (high oxygen)
  - Less fertilizing
  - Too high EC of growing media

Water quality guidelines for transplant

pH	5.5–6.5
Alkalinity CaCO3	60–80 ppm (mg/l)
Soluble salts (EC)	< 1.0 mmhos/cm
Sodium absorption ratio (SAR)	< 2
Nitrates (NO3)	< 5 ppm (mg/l)
Phosphorus (P)	< 5 ppm (mg/l)
Potassium (K)	< 10 ppm (mg/l)
Calcium (Ca)	40–120 ppm (mg/l)
Magnesium (Mg)	6–25 ppm (mg/l)
Sodium (Na)	< 40 ppm (mg/l)

- Chlorides (Cl) < 80 ppm (mg/l)
- Sulfates (SO4) 24–240 ppm (mg/l)
- Boron (B) < 0.5 ppm (mg/l)
- Fluoride (F) < 1 ppm (mg/l)
- Iron (Fe) < 5 ppm (mg/l)
- Manganese (Mn) < 2 ppm (mg/l)
- Zinc (Zn) < 5 ppm (mg/l)
- Copper (Cu) < 0.2 ppm (mg/l)
- Molybdenum (Mo) < 0.02 ppm (mg/l)

Source: Adapted from Curtice & Templeton, *Water quality reference guide.*

Nutrients

- High NH4 ➤ increase growth
- High NO3 ➤ not rapidly expand leaf, lower growth
- Fertilizer controls media pH
  - High NH4 ➤ acid
  - High NO3 ➤ basic
- Media pH = 5.5-6.5

Vegetable requires transplanting

1. Solanaceae (tomato, chiili, eggplant)
   - Cell tray
   - Transplant after sowing 25-35 days
2. Salad crops such as lettuce, celery
   - Cool season : direct seedling
   - Soil temp > 29 ^{o}C decrease seed germination

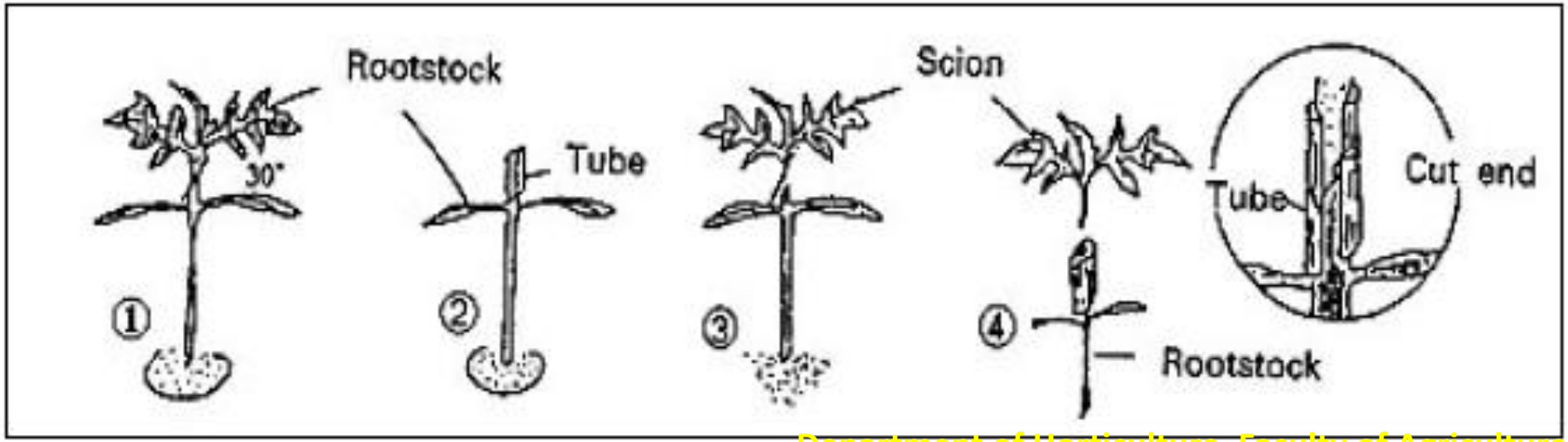
3. Cucurbit crops (hybrid seeds only)

4. Grafting (in some cases)

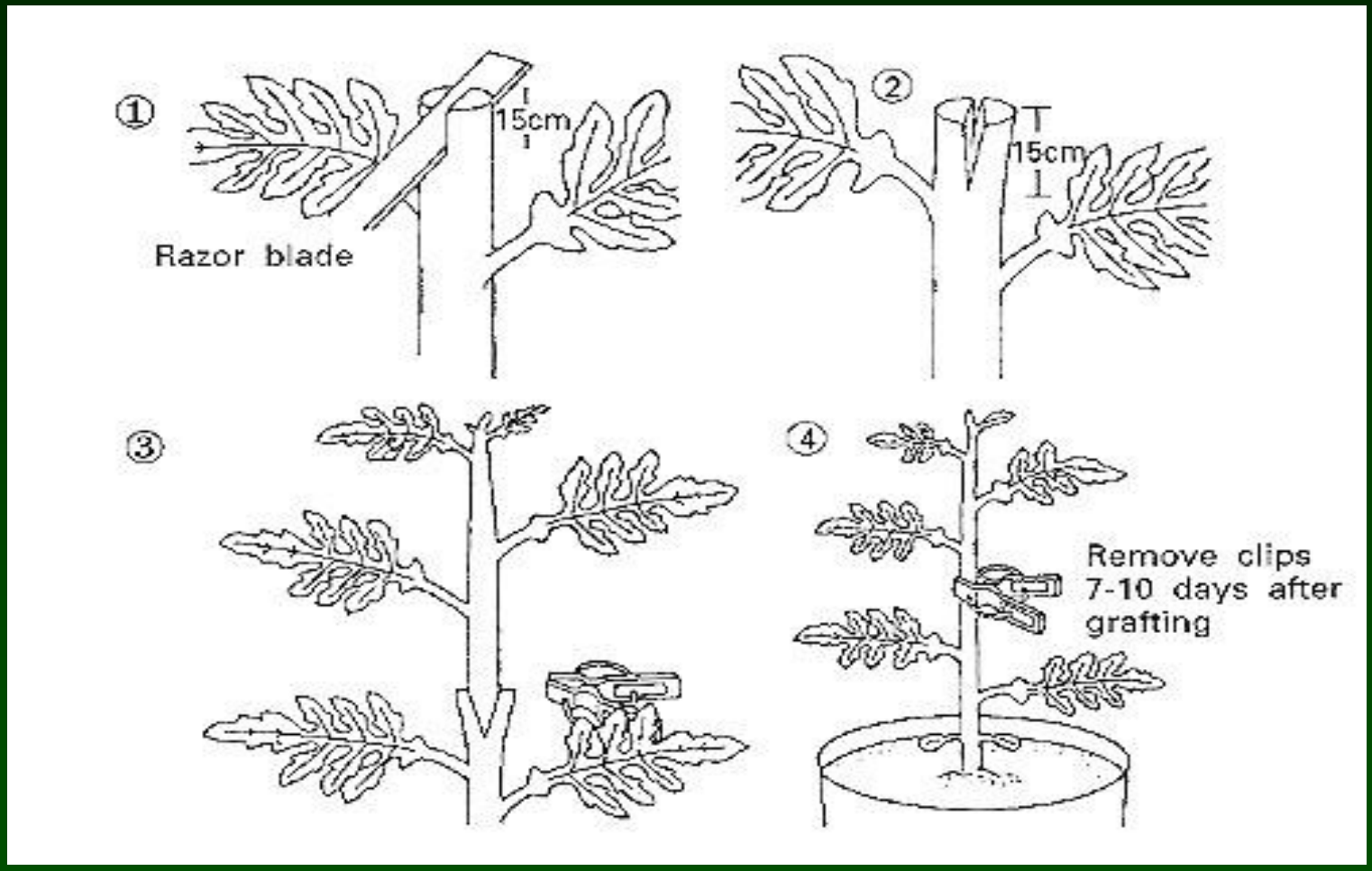
- Watermelon on bottle gourd
- Tomato on eggplant

Why vegetable requires grafting?

- To make plant resisting to soil-borne diseases, nematode, salinity, soil temperature
- To make plant able to nutrient absorption ability

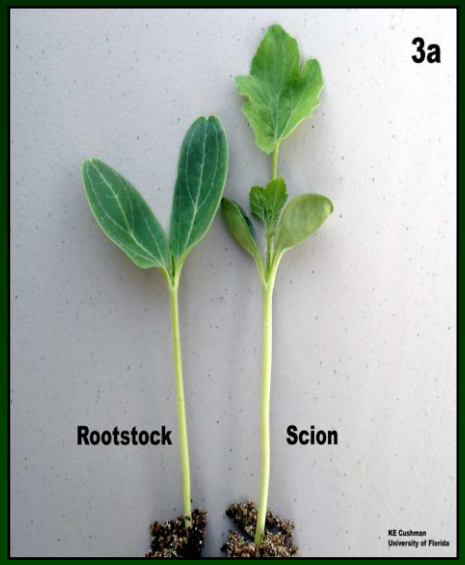


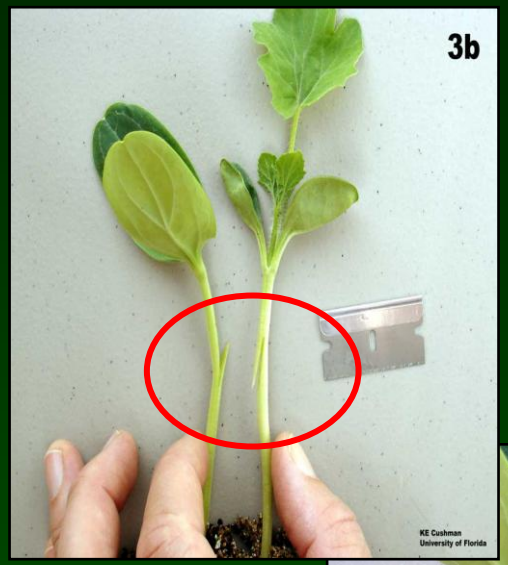
Cleft grafting

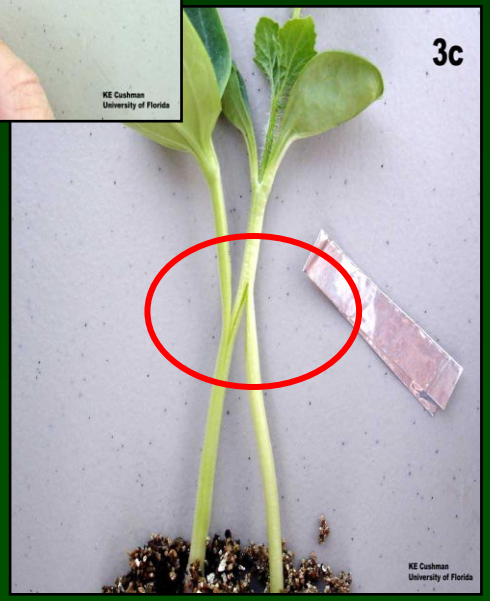


- http://www.hort.uconn.edu/ipm/greenhs/htms/Tomgraft.htm

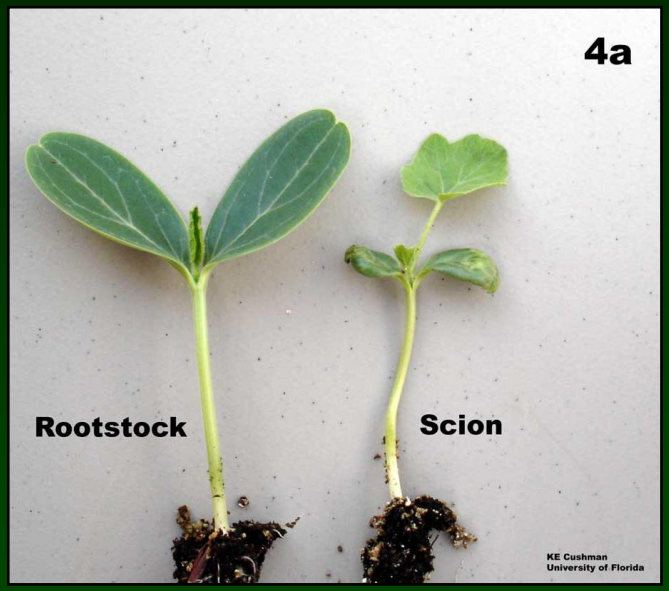
Tongue approach grafting

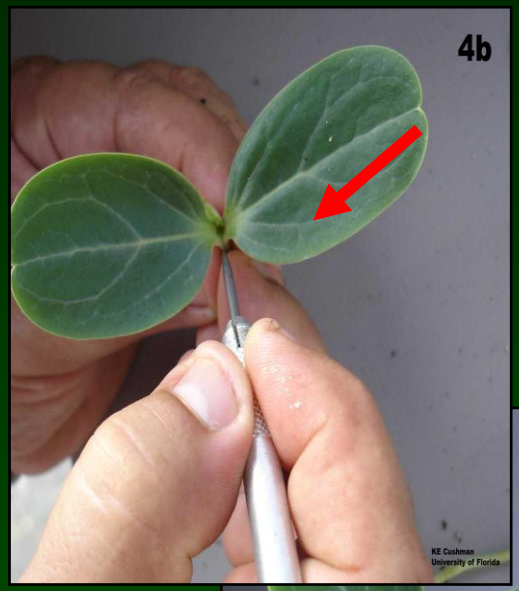


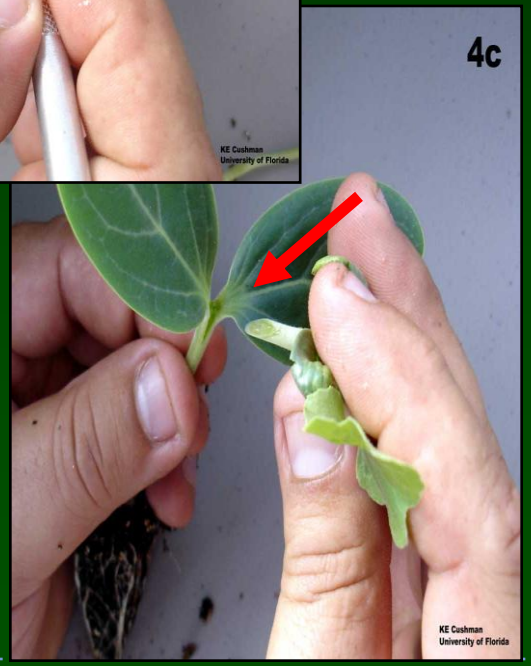


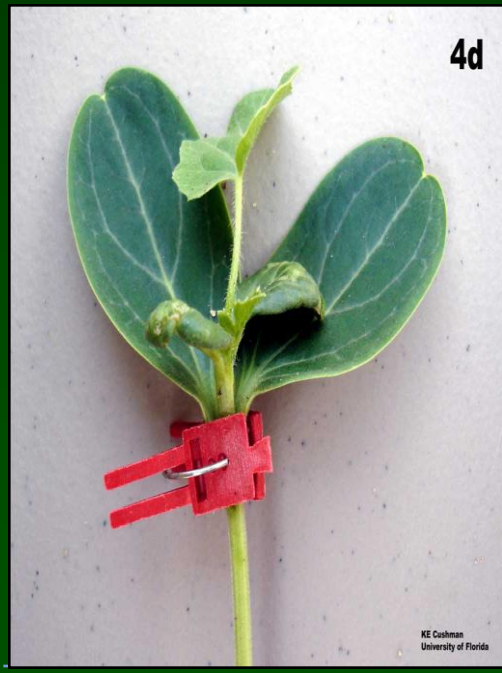


Hole insertion grafting









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Acclimatization of grafted seedling

- Stage 1
  - Temp. 20-25 °C, RH 85-95%
  - 45% Light for 6-7 days
- Stage 2
  - 85%light RH 70% (uncontrolled condition) 3-4 days
- Stage 3
  - 100% light 3-4 days
- Stage 4
  - Uncontrolled conditions (Greenhouse condition)


6 days


3 days


3 days


6 days

Grafting machine

Recommendation for raising seedling

- Selecting the proper plug cell sizes for your need (actually 72 or 104 cells)
- Filling the plug trays properly
- Placing a seed into the center of each cell
- Covering the seed uniformly, if necessary to cover
- Watering the trays properly

Transplanting

- Start transplanting when seedlings show the 1st true leaves
- Should be completed before the seedlings become larger and overcrowded
- "Ready" seedlings
  - Well rooting
  - Vigor roots

Things to do before transplanting

- All land preparation should be completed by the time seedlings are ready.
- “Ready” seedlings should not be kept beyond 2 before transplanting.
- One day before transplanting, let the media moisture decrease to hold the seedling growth.

Things to do before transplanting

- Apply heavy watering two hours before removal of seedling for transplanting
- Seedlings can be transferred to more convenient container for transporting to field

Controlling shoot and root growth

1. Shoot growth

1.1 Height

- single stem crops; internode length
- crown (rosette); petiole length

1.2 Leaf color

- Solid green ➤ normal
- Yellow ➤ underfed, stress, root rot
- Dark green ➤ high NH4
- Pale green ➤ low N, NH4 toxicity, low Mg

1.3 Leaf size or expansion

- Properly expanded
- Cover the tray before transplanting
- Small leaf size caused by
  - Low N
  - High chemical growth regulator
  - High light intensity
- Large leaf size; damaged during shipping and transplanting

1.4 Number of true leaf

- Too cool ➤ fewer true leaves
- Many true leaf ➤ old transplant/ warm grown/high NH4 fertilizer

1.5 Bud or bloom

- Old transplant/stressed transplant
- Delay vegetative growth after transplanting

2. Root growth

2.1 Pullability

- Easy to pull out from a tray

2.2 Root amount and location

- Roots located mainly in the top half of the plug cell can be a result of frequent, light waterings, with the bottom half staying too dry

2.3 Root hairs and root thickness

- Located mainly on the outside and bottom of the cell, long, thin roots indicate
  - overwatering or
  - a plug media with little air porosity

How to control the height

1. **Temperature**
   - Low temp (5-10 °c) ➤ slower and shorter transplant
   - Low temp should apply before flower budding
   - Cool water (5-15°c) reduces tomato and cabbage plant height

(Chen et al., 1999)

2. Moisture

- **Low moisture**
  - Reduce growth
  - Slow flowering
  - Drought stress
- **High moisture**
  - Tall and weak seedling

3. Mechanical methods

- Objective to disturb the plant growth
  - Brushing; tomato
  - Shaking
  - Increasing air movement
- Stimulate ethylene production

4. Chemical growth regulators

- Internode elongation reduction
- Greener leaf
- Increase branching
- Increase root growth
- Slow down flowering
- daminozide, chlormequat chloride, ancymidol, paclobutrazol

How different?

Transplant production unit (Nae Terasu 苗テラス)

Temperature 20-25 °C RH 65-70%

CO_2 concentration 1200 ppm