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 seeding

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 success for direct seedling??

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

Direct seeding/broadcasting

2. Outdoor seedbed

Site selection

- Soil fertility
- Soil cleaning ; free of pathogen, insect pests
- Soil particles; aeration
- Shading?

Determine seeding rates

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

Media filling machine

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Pepper transplant production I

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Pepper transplant production II

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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

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How to get a high quality transplant

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

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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

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Coated seed Pelleted seed

+ chemicals + hormone + etc.

Uniformity/High germination/High vigor

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2. Growing medium

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

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Functions of growing medium

- 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

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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

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Media components

Vermiculite

Rock wool

Compost

Rice hull charcoal

Perlite

Coir dust

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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

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

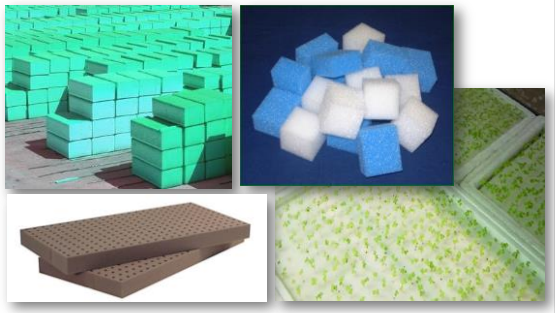
- improve drainage
- a wide range in particle sizes, generally use medium to coarse sands (0.25 to 2 mm)
- High bulk density

4. 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

Other materials

Synthetic materials ; plastic



Properties of growing medium

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

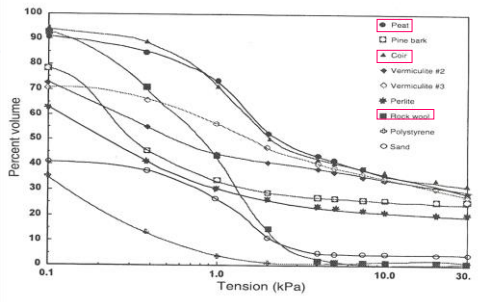
Physical properties of various media

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

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

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 air porosity-water holding capacity 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
  - Melon/water melon/pumpkin
- 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

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

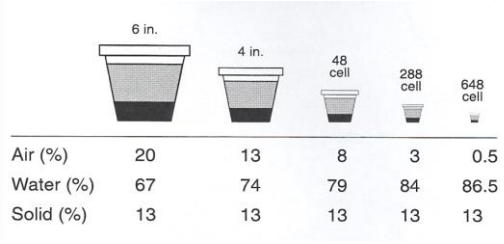
Advantages of using container/cell tray

- 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

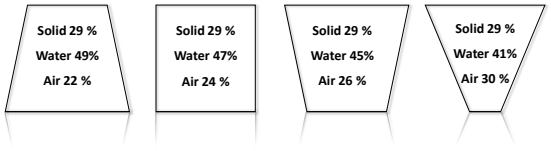
Disadvantages of using container/cell tray

- Grower required to change production method
- More difficult to produce plugs yourself, as opposed to buying them
- 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



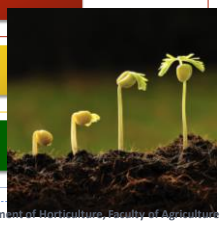
Air (%)	20	13	8	3	0.5
Water (%)	67	74	79	84	86.5
Solid (%)	13	13	13	13	13



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



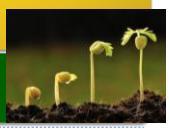
Stage of transplant growth

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

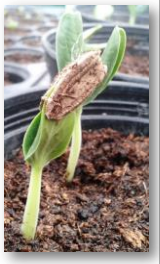
- Low root zone temperature ➡ slow down growth,
  - NH_4 accumulation ➡ toxicity
- High root zone temperature
  - NH_4 will be used quickly
  - Stretched and soft shoot growth

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

Relative 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



Medium 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 medium

Water quality guidelines for transplant

pH	5.5–6.5
Alkalinity $CaCO_3$	60–80 ppm (mg/l)
Soluble salts (EC)	< 1.0 mmhos/cm
Sodium absorption ratio (SAR)	< 2
Nitrates (NO_3)	< 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 NH_4 ➤ increase growth
- High NO_3 ➤ not rapidly expand leaf, lower growth
- Fertilizer controls media pH
  - High NH_4 ➤ acid
  - High NO_3 ➤ basic
- Media pH = 5.5-6.5

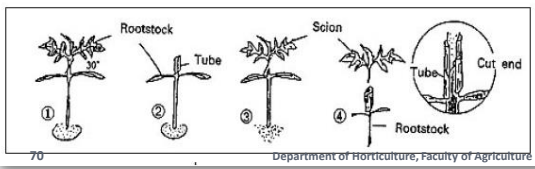
Vegetable requires transplanting

1. Solanaceae (tomato, chili, 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?

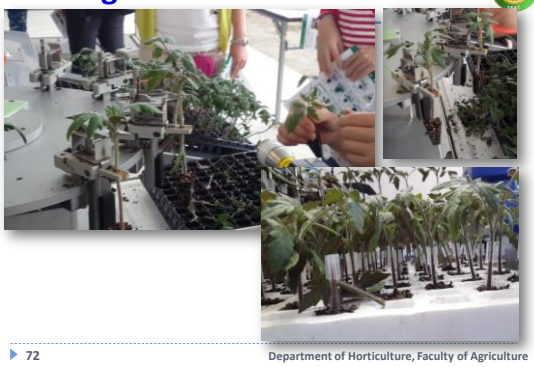
- To make plant resisting to soil-borne diseases, nematode, salinity, soil temperature
- To make plant able to nutrient absorption ability



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) for 3-4 days
- Stage 3
  - 100% light for 3-4 days
- Stage 4
  - Uncontrolled conditions (Greenhouse condition)

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 days 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 NH_4
- Pale green ➤ low N, NH_4 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