Plant Propagation PLS 3223/5222

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The Propagation Environment

Chapter 3
Chapter 3 Objectives are to Understand:

- How environmental factors affect propagation
- Propagation structures
- Containers used for propagation
- Management of media and nutrients
- Management of biotic factors

Enhancing Propagation of Plants

Microclimatic conditions

Edaphic factors

Biotic factors
**Microclimatic Conditions**

-Any environmental factor (relative humidity, temperature, light, gas, etc.) in the immediate vicinity of the propagule during propagation

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**Propagation for the Future**

CEAC, University of Arizona - South Pole Project

Kennedy Space Center - NASA Research Lab
Measuring Light

**Irradiance**
- the relative amount of light as measured by radiant energy per unit area (energy content)

**Light intensity**
- light given off by a point source

**Light photosynthetic active radiation (PAR)**
- radiant energy capable of causing photosynthesis and measured as photosynthetic photon flux (PPF)
**Photosynthetic Photon Flux**

- Photosynthetically active radiation

- Reported as micromoles of photons per unit area per time (µmol m\(^{-2}\) s\(^{-1}\)).

- Measured with a quantum sensor in the 400-700 nanometer waveband.

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**Measuring Light**

- **Light Quality**
  - Spectroradiometer

- **Light Intensity (PAR)**
  - Light Meter with Quantum Sensor
Light

• All light is made up of energy
• Light to humans is the wavelengths of radiant energy in the electromagnetic spectrum that activates the light receptors in our eyes.
• Light to plants is all of the wavelengths that human’s can see and some wavelengths that humans can’t see.

Light Manipulation

• Supplemental lighting- high intensity discharge lamps (HID)

Outdoors 1700-2000 µmol m$^{-2}$ s$^{-1}$
Shady day  60-100 µmol m$^{-2}$ s$^{-1}$
Artificial light  20-80 µmol m$^{-2}$ s$^{-1}$
(fluorescent or incandescent)
Shading

- Light reduction

Kraft Gardens, Fort Pierce, FL

Daylength (Photoperiod)

Photoperiodism

- response to duration and timing of day and night
- a mechanism evolved by organisms for measuring seasonal time
Daylength

Long day plants
• flower primarily in the summer when the critical photoperiod of light is equaled or exceeded

Short day plants
• flower when the critical photoperiod is not exceeded

Day-neutral plants
• reproductive growth is not triggered by photoperiod

Photoperiod

Short Day Long Day
Chrysanthemum Spinach

Raven et al., 1999
Yoder Brothers
Chrysanthemum Production

- Manipulating photoperiod

Light Quality

- Perceived by the human eye as color and corresponds to a specific range of wavelengths
The Electromagnetic Spectrum

White light
Visible light

Raven et al., 1999

Phytochrome

• A photomorphogenic receptor
• Detects wavelengths from 300 to 800 nm
• Maximum absorption in red (R, 600 to 700 nm) and far-red (FR, 700 to 800 nm)
Light Quality

Red

Far-red

Synthesis $\Rightarrow$ Pr $\Leftrightarrow$ Pfr $\Rightarrow$ Biological Response

Spectral Plastic Greenhouses
Shorter, more compact plants

• By manipulating the red and far-red light in the greenhouse, height of greenhouse crops can be controlled.

Spectral Distribution

![Spectral Distribution Chart]

- Control
- $A_{FR}$
- $A_{R}$

Wavelength (nm)
Zinnia-22% height reduction (Wilson and Rajapakse, 2001)

Response of *Gaillardia pulchella* to Sumagic -uniconazole drench) (Hammond, Wilson et al., 2007)
Humidity, Temperature, and Gas Exchange

**Mist beds**
- increase humidity

**Bottom heat**
- increases rooting

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**Greenhouses**

**Cooling**
- Fan and pad
- Roof ventilation

**Heating**
- Hot air convection or gas-fired infrared
- root zone heating-below bench
- solar heating
Computerized Environmental Control

Carbon Dioxide Enrichment

\[ \text{CO}_2 + \text{H}_2\text{O} + \text{light energy} = \text{CHO} + \text{O}_2 + \text{H}_2\text{O} \]

- Increasing CO\(_2\) can result in a 200% increase in photosynthesis and therefore increased dry weight.
Carbon Dioxide Enrichment (Heo, Wilson et al., 2000)

Photoautotrophic (Forced Ventilation System)

Photomixotrophic (Conventional Agar)

Greenhouse Covering Materials

Glass

• Expensive
• Permanent
• Superior light transmitting properties
• Can be ‘white washed’
• Glass “breathes”
Greenhouse Covering Materials

Polyethylene

- 50% of greenhouses
- Light weight, less supporting framework
- Relatively inexpensive
- Short life, breaks down in sunlight
- New poly’s have UV inhibitors so can last longer (3-4 yrs)
- Heat retention
- Transmits 85% of sun’s light

Greenhouse Covering Materials

Polycarbonate

- The most widely used structured sheet material today
- 90% light transmission
- Diffuses light and reduces condensation drip
- Will resist long outdoor exposure (10 yrs.)
Controlled Environment Greenhouses-
Almeria, Spain

Eurofresh Inc.,
Wilcox, Arizona
**Closed-case Propagation**

**Hot Beds**
- flats are placed on top of hot-water tubing or electric heating cables

**Cold Frames**
- good for conditioning or hardening liners prior to planting

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**Lathhouses (Shade houses)**

- Provide outdoor shade and protect container-grown plants from high summer temperatures and high light irradiance.

- Reduce moisture stress and decrease the water requirements of plants.
Enhancing Propagation of Plants

**Microclimatic Conditions**
- RH
- Temperature
- Light
- Gases

**Edaphic Factors**
- Medium
- Nutrients
- Water

**Biotic Factors**
- Interaction with other organisms

Soilless Media

- Firm, dense to hold cuttings in place
- Easy to wet and retain moisture
- Porous to penetrate oxygen to the roots
- Free from weed seeds and pathogens
- High capacity for nutrient retention
- Consistent from batch to batch
- Readily available and acceptable cost
**Physical Properties**

- **Bulk Density**
  - The mass of dry soil per unit bulk volume including the air space

- **Container Capacity**
  - The ability of soil per unit bulk volume to hold water

- **Air filled Porosity**
  - The proportion of the bulk volume of soil that is filled with air under a given condition

**Physical Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Calculation</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>BD (g/cm³)</td>
<td>Dry weight ÷ Sample volume</td>
<td>0.1-0.3</td>
</tr>
<tr>
<td>CC (% by vol)</td>
<td>(Wet weight - Dry weight) ÷ Sample volume</td>
<td>40-80%</td>
</tr>
<tr>
<td>AFP (% by vol)</td>
<td>(Vol. water drained x 100) ÷ Sample volume</td>
<td>15-20% (pot) 2-10% (plug)</td>
</tr>
</tbody>
</table>
Other Properties of Media

**pH**
- The negative logarithm of the hydrogen-ion activity of a solution; degree of acidity or alkalinity of a medium

**EC**
- Measure of total soluble salts (electrical conductivity) of the medium

**CEC**
- Ability of a medium to hold and exchange nutrients (cation exchange capacity)

Soilless Media

- Premixed and bagged
- Mixed on site or bulk delivered
Soilless Media

- Organic
  - peat, softwoods, sphagnum moss
- Mineral component
  - used to improve drainage and aeration
  - sand, perlite, vermiculite

Some Components of Media

- Sand
- Peat
- Perlite
- Bark
- Coir
  - Synthetic plastic aggregates
- Compost
**Peat**

- High water and nutrient holding capacities
- Hard to rewet once dry
- For lightweight, short-term mixes
- Acidic
- Some variability in location

**Perlite**

- Expanded volcanic rock granules
- Sterile, inert, and light
- Retains some moisture but drains freely
- Used to increase air space
- Medium/coarse grades
Vermiculite

- Expanded and air-blown mica
- Acts similarly to perlite but holds more water and less air
- Breaks down over time
- Fine and regular grade
- K, Mg, Ca

Shredded Bark

- Fine grades of chipped bark
- Relatively inexpensive, available (becoming more expensive)
- Increases bulk density
- pH 5.0-6.5
**Coir**

- Fiber from coconut husks (waste by-product)
- Dries out less quickly than peat
- High air and water holding capacity
- Ph 5.5-6.5

**Sand**

- Helps drainage
- Coarse and fine grades
- Adds weight to pots
- No buffering capacity or CEC
Compost

- 1:1 biosolids: yardwaste, manures
- pH 6.7-7.7 (varies)
- Can improve physical, chemical and biological properties of soils

Media Amended With Compost (Wilson and Stoffella, 2002)

100% 75% 50% 25% 0% Compost
Containers for Propagating and Growing Young Liner Plants

**Flats**
- Plastic
- Styrofoam
- Wooden
- Metal

**Plug/Liner Flats**
Containers for Propagating and Growing Young Liner Plants

**Fiber pots**
- biodegradable

**Synthetic rooting blocks**
- serve as the pot and potting mix
- well adapted for automation

Pots for Containerized Production
Chemical Root Pruning

Figure 3-23 (Hartmann et al., 2011)

Nutrition

- Cuttings are normally fertilized with slow-release fertilizers that are either pre-incorporated into the propagation medium or broadcast across the medium surface.
- Soluble fertilizer is applied after roots are formed generally by fertigation.
Fertilizers

Nitrogen
- vegetative shoot growth

Phosphorus
- root development
- photosynthesis

Potassium
- plant water relations

Slow release vs. liquid

Irrigation Water

- Most producers regularly monitor electrical conductivity (EC) and pH of their irrigation water
- High salts affect physical properties and water-absorption rates of soils
- pH influences nutrient availability (5.5 to 7.0 is best)
**Best Management Practices (BMP)**

- Collect runoff water when injecting fertilizer
- Apply fertilizer and water only when needed and monitor quantity used
- Do not broadcast on spaced containers or containers prone to blow over
- Group plants in a nursery according to water and fertilizer needs
- Recycle runoff water

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**Dr. Tom Yeager, 2007**
Enhancing Propagation of Plants

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**Biotic Factors**

Biological organisms that interfere with plant production

- bacteria
- viruses
- fungi
- insects/mites
- nematodes
- weeds
- birds/mammals
Pathogen and Pest Management

Pathogen and pest management begins prior to propagation

A stressed propagule is much more susceptible to pest problems

- use clean plants (stocks), media and pots
- cultivar resistance
- scouting

Integrated Pest Management

IPM uses as many management (control) methods as possible in a systematic program of suppressing pests, i.e., targeted control.

- Chemical- pesticides, fumigants
- Biological- Bacillus thuringiensis (BT)
- Cultural-microscreening
Web-based Lecture
Dr. Gene Giacomelli-
University of Arizona

Greenhouse Systems for Plant Production- Part I
Ventilation and Cooling- Part II
Environmental Control Video at Knox Nursery

Knox Nursery, Winter Garden, FL (web-video)

• Second-generation family-run business started in 1962
• Produces over 150 million plugs and liners from over 700,000 square feet of high-tech greenhouses
• Over 5000 varieties of bedding plants