Plant Propagation PLS 3223/5222

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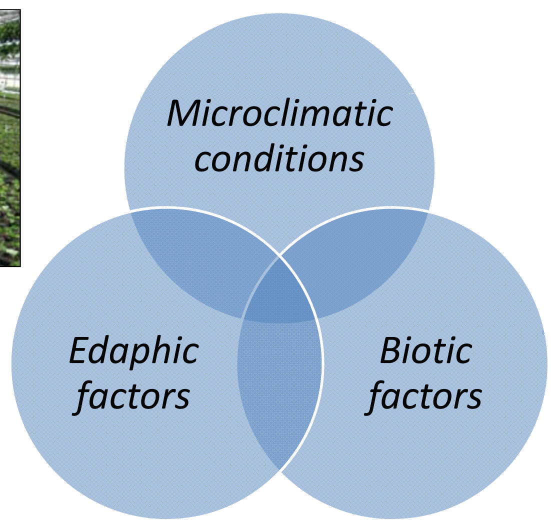
The Propagation Environment

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

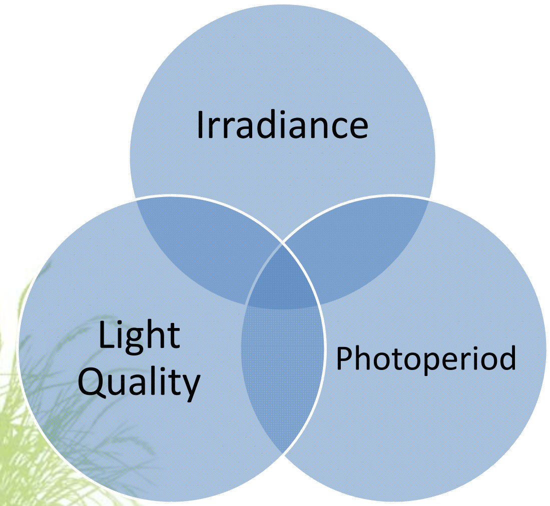
-Any environmental factor (relative humidity, temperature, light, gas, etc.) in the immediate vicinity of the propagule during propagation

Propagation for the Future

CEAC, University of Arizona -South Pole Project

Kennedy Space Center-NASA Research Lab

Light



Holland- Cloudy days

Arizona- Sunny days

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.

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

Short Day Long Day

Spinach

Raven et al., 1999

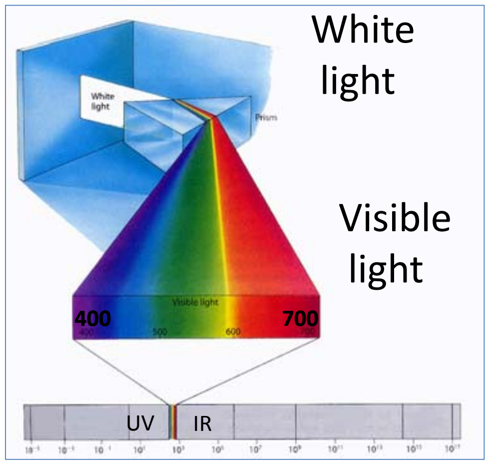
Yoder Brothers Chyrsanthemum Production

- Manipulating photoperiod

Light Quality

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

The Electromagnetic Spectrum

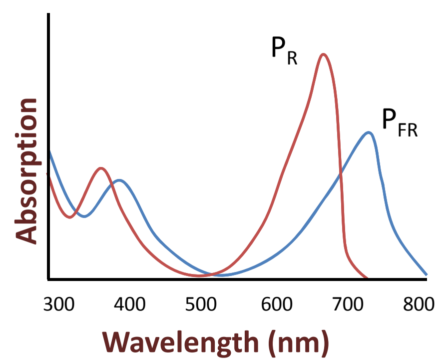


Wavelength

Raven et al., 1999

Phytochrome

- A photomorpho-genic 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)

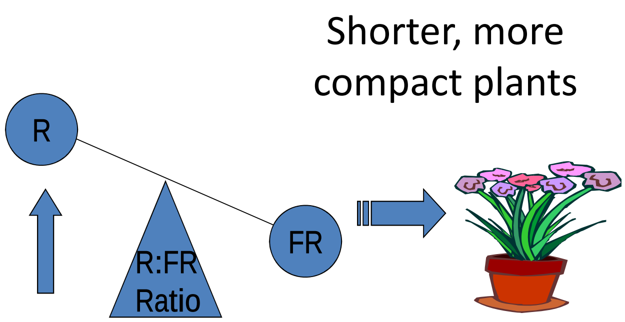
Light Quality

Red

Far-red

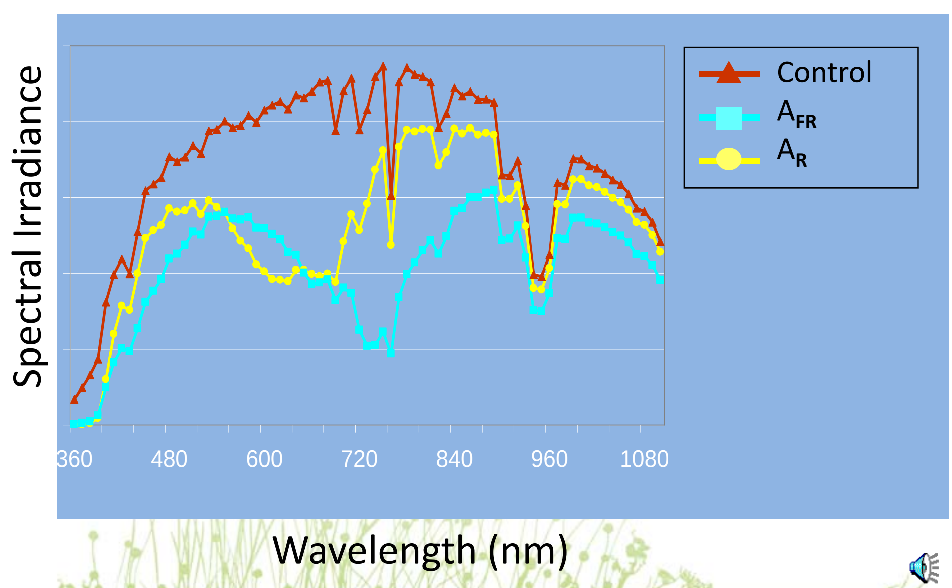
Synthesis ⇒ Pr ⇔ Pfr ⇒ Biological Response

Spectral Plastic Greenhouses

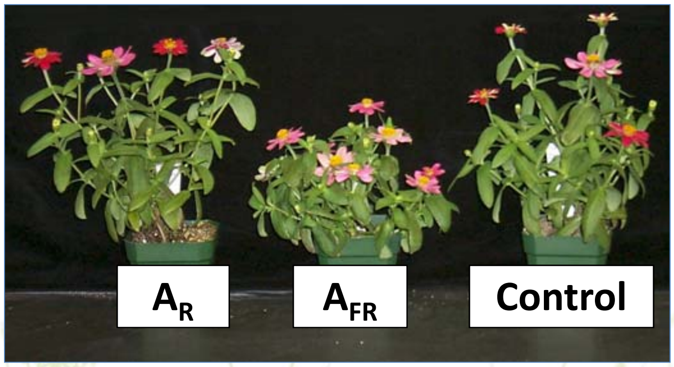


- By manipulating the red and far-red light in the greenhouse, height of greenhouse crops can be controlled.

Spectral Distribution



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



Response of *Gaillardia pulchella* to Sumagic -uniconazole drench) (Hammond, Wilson et al., 2007)

Control 6 mg/L 12 mg/L 24 mg/L

Humidity, Temperature, and Gas Exchange

Mist beds
- increase humidity

Bottom heat
- increases rooting

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

CO_2 + H_2O + light energy = CHO + O_2 + H_2O

- 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)

Photoautotrophic (Natural Ventilation)

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

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

Property	Calculation	Range
BD (g/cm^{-3})	Dry weight ÷ Sample volume	0.1-0.3
CC (% by vol)	(Wet weight - Dry weight) ÷ Sample volume	40-80%
AFP (% by vol)	(Vol. water drained x 100) ÷ Sample volume	15-20% (pot) 2-10% (plug)

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

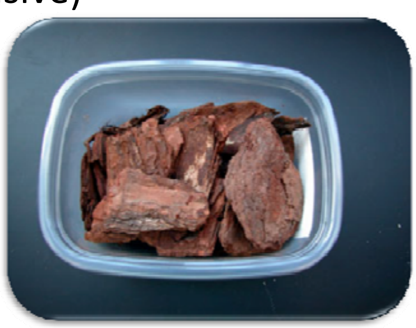
- Expanded volcanic rock granules
- Sterile, inert, and light
- Retains some moisture but drains freely
- Used to increase air space
- Medium/coarse grades

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

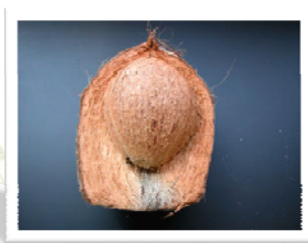
Shredded Bark

- 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)

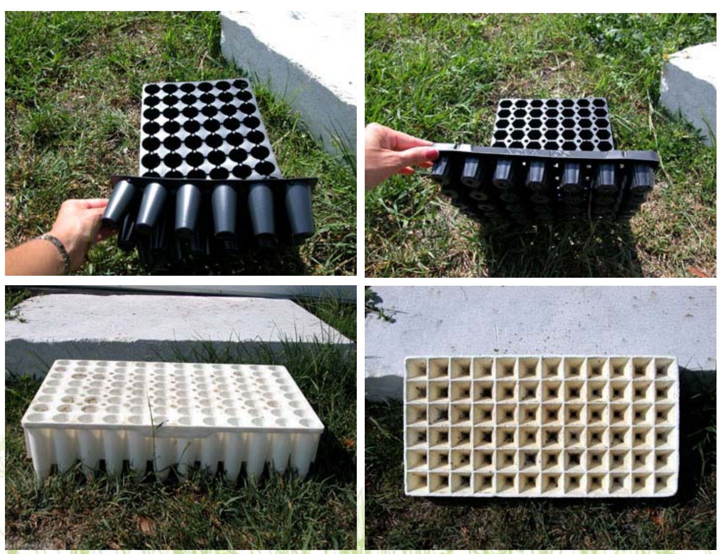
100% 75% 50% 25% 0% Compost

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

15-9-12 N-P-K

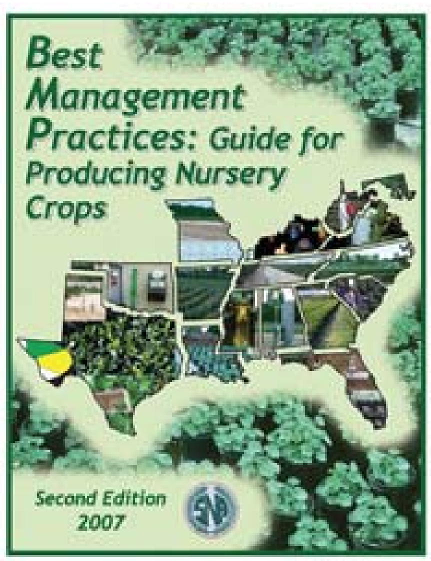
Irrigation Water

- 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

Dr. Tom Yeager, 2007



Enhancing Propagation of Plants

Microclimatic Conditions	• RH • Temperature • Light • Gases
Edaphic Factors	• Medium • Nutrients • Water
Biotic Factors	• Interaction with other organisms

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