An Introduction to Small Protected Agriculture Operations

A PROFIT AND PRODUCTION WORKSHOP
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Objectives
- Introduce types of protected agriculture
- Become familiarized with greenhouse and production basics so that starting costs can be more accurately accounted for
- Learn some cost-saving techniques

Profitability
- Goal is to maximize profit per square foot
- Square foot of production space – the space that produces plants
- All inputs (overhead and direct) should be divided by the production square footage.
- Profits should be divided over production square footage
- Ensure a profit margin
- Square foot week
What is Protected Agriculture?

- Hoophouses / High Tunnel / Low Tunnel
- Greenhouses
- Any kind of protective structure creating a microclimate for the production of agricultural products
- May be heated or unheated

Purpose

- Extend season during low temperature months
- Allow for the growth of plants that require warmer temperatures, higher humidity, and low wind
- Some structures even serve to provide shade

Hoophouses

- High Tunnel – large raised structure spanning several field rows
- Low Tunnel – crop tunnel or row cover

- Very basic structure used to cover crops in the field
- Create warm microclimate by absorbing radiant sun energy and trapping heat
- Can also protect from precipitation and insects
Basic Greenhouse Structures

- “Structure covered with transparent material for the purpose of admitting natural light for plant growth.”
  
  Paul V. Nelson

- Consist of foundation, frame, glazing

- Can be self-constructed, ordered piecemeal, or bought in whole or as part of a package

- Have the capacity for ventilation and heating, even lighting

Structural Basics

- Can be made of wood, steel, aluminum

- Wood less common now, steel and aluminum more abundant

- Aluminum is rust resistant
Basic hoop house frames can be used

Wood-framed high tunnel

Wood-framed greenhouse
Metal piping supports the plastic covering over a wood-frame base.

Different materials can be used.

Basic hoophouse frame is modified with wood structure to provide an end wall supporting ventilation.
Very basic "cold-frame" can be used in field situation or placed on top of a foundation for a basic greenhouse.

Can still retrofit venting and heating units.
Structural Basics

Glazing

Glazing is the light-admitting material covering the structure.

- Glass was traditionally used but has now been largely replaced by plastics
  - More lightweight, better heat efficiency, lower cost
  - 2 types of plastic
    - Film
    - Rid

Structural Basics

Glazing

- Plastic Film:
  - Polyethylene – most common
  - Polyester
  - PVC
  - Often double-layered
  - Degrades in UV light, hindering transmission, shortening life
  - Maintenance cost with replacing (1-4 years)
An advantage of using film is the ease of side ventilation using roll-up sides.

Structural Basics

Glazing

- Second type: Rigid Panel
  - Polycarbonate - most common
  - Acrylic

Solexx® Covering is more flexible

Structural Types

Lean-To

- Placed against wall of building
- Should be placed on south side
- Minimal roof support needed
- Can be attached to garage for processing convenience
Standalone Greenhouses
Hobby Greenhouses

- Around 200 sq. ft. or less
- Can be very expensive for the space
- Good way to learn basics without large commitment
- Come in kits available for mail order
- Can also build your own
Standalone Greenhouses
Commercial and Teaching Greenhouses

- Larger, 500-3,000 square feet
- Sturdier
- Allow for ventilation and climate control systems
- Require foundation
- Can buy structure or packages that include vents, thermostats, fans, foundation, heaters.
- Can run $10,000 to over $30,000

Preparation

- Thoroughly research designs and pick what will work best for you and your climate, product.
- Make visits
- Have everything set up the season before you plan to grow. You do not want to be working out kinks while trying to grow at the same time. Some is inevitable.
Locating your greenhouse

- Level land (<5% slope)
- Sunlight availability
- Orientation for maximum sunlight availability
- Align ridge N-S
- Accessibility (consider business structure)
- Water quantity and quality

Expansion

- Energy availability
- Proximity to labor market
- Proximity to selling market (ease of access for customers, delivery trucks)
- Room for office space, storage, maintenance equipment...

What is needed to begin?

- Growing space
- Selling space
- Materials
- Labor
- Equipment
  - Mixers, delivery vehicles
- Time management
- Stock Material
- Regulatory compliance - visit Tennessee Department of Agriculture

Production Area

- Where and how you place plants within the structure is determined by your product.
- Pre-built greenhouse benches can be purchased for plant production
- Plants can also be placed on the floor or hung on trusses
- Do what works for you, keep plants out of standing water!
Greenhouse Benching

- Can be built or purchased
- Can also be constructed from wooden frames and wire mesh, or repurposed upside-down flats and wire cages
- Avoid materials that will quickly rust or rot, or harbor disease (wood)
- Galvanized steel and polypropylene are better materials
- Keep to 3 or 6' wide

Hanging Baskets

- Hanging baskets can be hung from benches or trusses, or specialized structures
- Will impede light interception by plants below
- Water and nutrients / disease inoculum can drip below as well
- Faust (Clemson Univ.) found they can block up to 22% of light at 1/2yd
  density, at full flush.
- Can be useful in combination with shade loving plants. Not to be placed above plants needing lots of sun. Seedlings etc.
When used for year-round production, structures often need supplemental climate control to decrease heat in the summer and increase heat during the winter (early spring, late fall).

- Extreme heat or cold can injure and kill plants.
- Optimum is 65-70°F, peak 76-80°F.
- According to Clemson, keep temperatures below 90°F to avoid injury.
- Increasing temperatures in this range can slow growth.
- Heating and cooling are among top costs.
Heating

- Most common method in smaller structures is unit heater
- Fuel used is most often natural gas, propane, liquid petroleum
- Usually heater-specific
- Boiler and central heating systems as well

Increasing Heating Efficiency

- Use double-layer materials (two layers of poly film, or use twin or triple-wall rigid paneling).
- Use windbreaks: Use plants (such as conifers) to shield the greenhouse from chilling winds.
- Section off the greenhouse: If only part of the greenhouse is needed for cold-temperature production, section it off using a plastic curtain and only heat the needed space.

Cooling

- Two general systems –
  - Passive ventilation
  - Forced air ventilation
  - Forced air with evaporative cooling (effectiveness is decreased with humidity)
Greenhouse heat can be further reduced by use of:
- Shade cloth
- Increasing the number of air exchanges to at least 1 – 1.5 per minute
Irrigation Systems

- System used will depend on size of growing space and resources available
- Many smaller operations hand-water, but requires labor and expertise
- Automated systems save time
  - Should be flexible, and should be monitored by the irrigation manager (probably YOU)

Components of irrigation system

- Water source
  - Will you need to drill a well?
  - Will you use municipal water?
  - Harvest rainwater?
  - Combination

*According to Texas A&M, expect to deliver 1.6 to 2.4 gallons per minute for each 1,000 square feet, or 8 to 12 gallons per minute for each 5,000 square feet of growing area
Have your water tested for:
- pH, alkalinity, electrical conductivity, total dissolved solids
  - Should be tested regularly, equipment available for in-house use
- Nitrate, phosphorus, potassium
- Sodium, chloride
- Fluorine
- Iron
- Many packages contain additional elements
- Test 2x per year, during wet and drought seasons

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Have adequate filtration for surface water:
- Strainer at intake
- Finer filter after the pump
  - Sand filtration
  - Cartridge / Basket Filter (75-200 mesh) (200 and finer for drip systems)
- Generally pump into holding tank for adequate pressure
- Work with an irrigation supplier or contractor to determine your needs
Components of irrigation system

- Filtration, fertigation, acid injection systems
  - For automated drippers, filtration will be required to reduce the incidence of clogs
  - Fertigation is the delivery of soluble fertilizer through the irrigation lines
  - Acid injection is the addition of acid (phosphoric, sulfuric) to reduce the negative effects of alkaline and high pH water
  - BACKFLOW PREVENTION - to prevent siphoning chemicals and fertflows back into water source

Components of irrigation system

- Once water supply is provided, use valves and controls to direct to production area.
- Always check valve specifications to match your pressure and flow to your needs.
- Make sure valves and components are protected and easily accessible.
- Be sure to have backflow prevention installed upstream of chemical entry.
Components of an irrigation system

- **Piping and Delivery**
  - Most often PVC, then drip tube/tube and emitter systems.
  - May need pressure regulation.

- **Controllers**
  - Can be set to come on as needed by the type of plant.
  - Will need to be adjusted for stage and time of year and type of plant.

**Flexible Poly Tubing (1/2")**
Solenoid Valves (24VAC)

- Small valves appropriate for small zones in greenhouses.
- 15 – 150 psi
- Use pressure regulator to reduce pressure below 50psi for use with drip irrigation equipment
- Use filter to reduce clogging with low flows
Water Delivery to Plants

- ½” inch tubing is punctured and emitters are inserted
- Emitters control flow
- Attach emitter/spaghetti tubing to emitter to bring water to plant (¼”)

Sprayers, Misters, Dippers

- Emitter tubing is inserted into various water delivery devices depending on desired application pattern
- Stakes
- Dippers
- Misters
- Kits available as well

Drip tape has emitters in the tubing

- Drip tape is used
- Emitters are in the tubing
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**Irrigation System Design**

- Divide irrigation systems into zones
  - Zones should combine plants with similar water requirements
    - Stage of growth (seedlings, cuttings, mature plants)
    - Plant type (herbaceous vs. woody; variety)
    - Container type (plug trays vs. #1, #3, etc.)
    - Mix/substrate type (heavy/coarse vs. fine)
  - Each zone has a separate solenoid valve and separate station on the controller

**Irrigation**

- Plants are more often over-watered than under
- Overirrigation depletes root zone of oxygen and fosters growth of root pathogens
- Examples: pythium, phytophthora, bacterial wilts

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**Main Shut-Off Valve**

- Pressure Regulator
  - <50 PSI for drip irrigation systems

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Irrigation Scheduling

- Do not excessively leach the growing substrate
- Water often enough to prevent substrate drying out
  - Hydrophobicity - dry substrate becomes increasingly difficult to hold water
- Uniformity is key
- Pressure loss throughout the system affects actual application rate

Substrate and Water Dynamics

- Just like soils, substrates have solid, liquid, and air portions.
- Liquid + air = pore space
- Pore space:
  - 100% water = saturation
  - Allowed to drain = water holding capacity
- Does not need to be at WHC all the time. But WHC needs to be replenished daily.
  - Depends on substrate and on the water needs of plants
- Substrates should not be allowed to completely dry out

When to water

- Morning is best – allows foliage time to dry out
- During summer, or periods of increased heat stress, PM watering can alleviate heat stress and aid growth
- Never water late afternoon, evening, or night
- Water thoroughly and only water again when needed
- Learn the signs of drought stress for your crops and apply water just before that point
  - Slight wilting, possibly discoloration
Water Quality

- Water quality is extremely important to plant growth
- Test water initially and at least twice a year - instruments are available from grower's supply outlets
  - pH - concentration of Hydrogen ions
    - Affects availability of nutrients in substrate
  - Electrical Conductivity - soluble salts
    - High salts affect the plant's ability to absorb water
  - Alkalinity - Carbonates and Bicarbonates
    - High levels increase the pH of water over time, and therefore nutrient availability
  - Hardness - Calcium and Magnesium
    - Similar to alkalinity, raises the water pH over time
    - Ratio is important – excessive Calcium can block uptake of Magnesium, causing deficiency symptoms.

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Nutrient Availability in Soilless Mixes

- Again - know your water quality! (pH, EC, alkalinity)
- Ammonia (NH4) fertilizers will generally lower substrate pH
- Nitrate (NO3) fertilizers will generally raise substrate pH

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Table 6-1: Guidelines for Growers: Irrigation Water

<table>
<thead>
<tr>
<th>Table 6-1: Guidelines for Growers: Irrigation Water</th>
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</thead>
<tbody>
<tr>
<td>Electrical conductivity (EC)</td>
<td>0.5 - 1.5 mS/cm</td>
<td>1.5 - 3.0 mS/cm</td>
</tr>
<tr>
<td>Acceptable</td>
<td>Unacceptable</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.0 - 7.5</td>
<td>6.5 - 8.0</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>1.0 mmols/l CaCO3</td>
<td>1.5 mmols/l CaCO3</td>
</tr>
<tr>
<td>Hardness</td>
<td>0.5 mmols/l CaCO3</td>
<td>1.0 mmols/l CaCO3</td>
</tr>
<tr>
<td>Calcium and magnesium</td>
<td>2.0 mmols/l</td>
<td>4.0 mmols/l</td>
</tr>
<tr>
<td>Specific conductance (maximum allowable levels)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sediment</td>
<td>50 ppm</td>
<td>250 ppm</td>
</tr>
<tr>
<td>Chloride</td>
<td>50 ppm</td>
<td>250 ppm</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.5 ppm</td>
<td>5.0 ppm</td>
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<tr>
<td>Aluminum</td>
<td>0.5 ppm</td>
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</tr>
<tr>
<td>Iron</td>
<td>2.0 ppm</td>
<td>10 ppm</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.5 ppm</td>
<td>5.0 ppm</td>
</tr>
</tbody>
</table>

To pH levels 5.0 to 7.0 experts handle, it is advised to manage the substrate pH using a pH meter and pH buffer packs. The pH level should be adjusted to the level of the substrate and the nutrient solution. This is usually done 1 to 2 times a day to maintain the pH level.
Growing

- Some finished products
  - Plugs / liners - seedlings to be sold to other growers for finishing
  - Finished plants
  - Transplants - bedding plants, vegetable transplants

- Choosing your crops
  - Make sure there is a market for them
  - Each has unique crop production schedule and cost
  - Consult trade and home magazines
  - Learn everything you can about what you are growing

Propagation Materials

- Containers
  - Plug Trays
  - Flats
  - Liners
  - Plastic Pots
  - Hanging baskets
  - Pouches
  - Decorative
  - Biodegradable
  - How does your customer base like to buy?

Plug Trays
Propagation Materials
Growing Substrate

- Referred to as “media” or “substrate” (NOT “soil”)
- Usually a peat-based mixture, acidic in nature
- Pine bark, perlite, vermiculite
- Less commonly rockwool, rice hull ash, etc.
- When packaged, usually contains starter fertilizer
- Common brands – Fafard, Jolly Gardener Pro-mix, Berger

Important characteristics

- Weight
- Drainage
- Water Holding capacity
- Cation exchange capacity
- pH
- Particle size distribution
  - Smaller for smaller containers

Substrate handling

- Handling large volumes and the need to mix components and amendments necessitates certain equipment
  - Mixers
  - Filling machines
  - Conveyor belts
  - Potting tables
- Amendments
  - Fertilizer, lime, controlled release fertilizers
Fertilization

- Packaged mixes usually contain starter “charge” of fertilizer that will last 1 – 2 irrigations
- Supplemental fertilizer should be provided in the form of controlled release granules (CRF) or liquid-feeding of soluble fertilizer through the irrigation lines (fertigation)
- Type and timing depends on plant needs, water quality, and substrate pH

Propagation Materials

- Plant Material
  - Source material
    - Seeds
    - Liners/plugs - vernalized perennials shorten turnaround
    - Cuttings
    - Seeding equipment - Wands, plates, automated machines

Pesticides

- Chemicals may need to be used to control insects, weeds, and disease
- To reduce chemical application and associated costs, always have a preventative attitude
  - Good sanitation
  - Monitor incoming material for pests and disease
  - Avoid over-irrigation
  - Discard diseased and dead plant material
  - Control weeds as they can serve as reservoir for disease and alternate host for insects
  - Routinely inspect and clean greenhouse equipment, structures, etc.
Production Cycles

- How do we time the production of greenhouse crops?
  1. Decide on the desired finish date
  2. Consult crop guides to get a production timeline/schedule
  3. Work backwards from there
     - Use the week-numbering system (first week of January = 1, last week of December = 52)
  4. Use a spreadsheet to plan activities related to production of crop
     (Robbins Publication)
- Crops may turn out on time or not, important to keep schedules and notebook of all activity, and results, overtime you will learn

Production Cycles

- Use your greenhouse production schedule to determine the income potential of operation
- Keep in mind indirect costs associated with owning the business (insurance, depreciation, etc.)
- Indirect, overhead, should be added up and distributed over production space
- Think about crop turnover – the longer a crop is in your hands, the more it will cost (heat, water, fertilizer, maintenance and labor, space)

Increasing that profit margin...

- Remember – you want the highest profit per square foot per season
- Analyze the cost and benefit of your practices
  - Does growing your own plugs save money if you must sacrifice one turnover?
  - Vegetable transplants are low-return, but quick turnaround
- Reduce labor – streamline processes, good site layout
- Substrate handling – automated machines? Are paths to growing space easily traversed?
- Irrigation – Many growers spend most of their time watering by hand. Automated irrigation often pays for itself after one growing season and frees time to take care of other things
- Plant handling, packaging, shipping – are routes in greenhouse to packing and shipping areas easily traversed?