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Growing Lettuce and Culinary Herbs Hydroponically

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Growing Lettuce and Culinary Herbs Hydroponically

Why grow lettuce and herbs?

- There is an increased interest in food produced locally
- There are several food crops that can be grown in a greenhouse
  - Tomatoes
  - Cucumbers
  - Strawberries
  - Peppers
  - Lettuce
  - Herbs

Lettuce and Herbs

- Lettuce and herbs are produced for their leaves
  - All other crops are produced for their fruits
- The time to produce is much shorter compared to fruiting crops
- The short crop times allow for "gap" production
  - Alternatives for fall and winter production

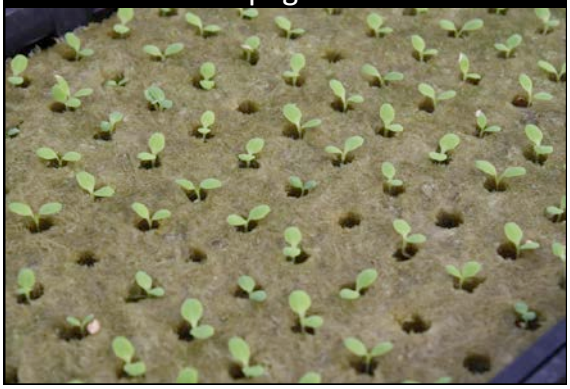
Cultivars

- So what should you grow?
  - The stuff that sells!
- Lettuce
  - Butterhead, loose leaf, romaine
- Herbs
  - Annuals: basil, dill, cilantro, flat-leaf parsley
  - Perennials: rosemary, sage, oregano, chive, thyme

Butterhead lettuce

Sweet or Italian basil

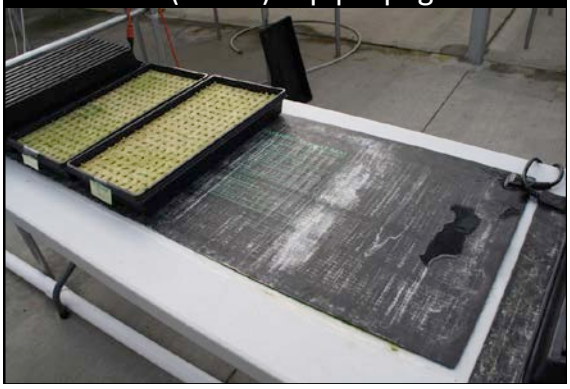
Propagation



Propagation

- Propagation of lettuce and many herbs is with seed
  - Some herbs are propagated with cuttings
- A number of different substrates can be used
  - Rockwool
  - Phenolic foam (Oasis®)
  - Stabilized peat or coconut coir
- Seedlings can be grown on the bench or in systems

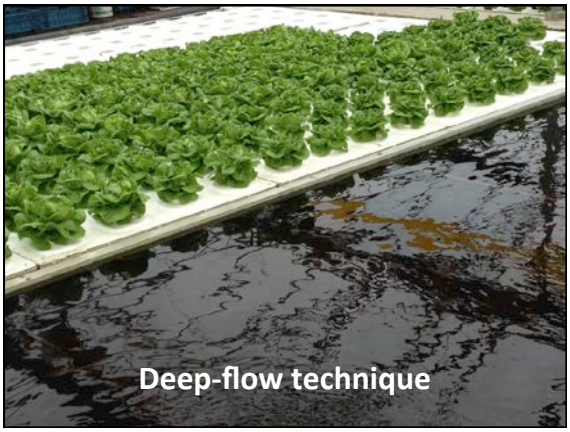
Bench- (table-) top propagation



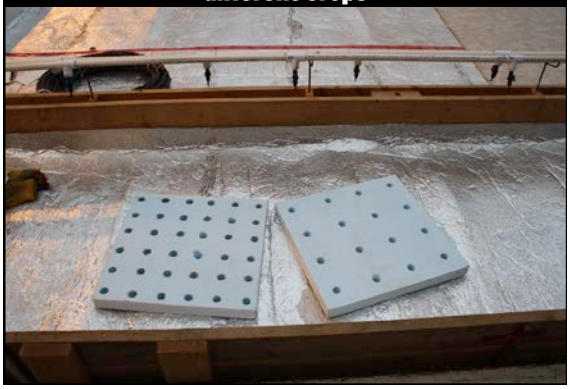
Propagation systems

Systems

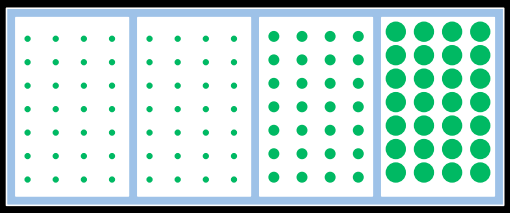
- Now that you have seedlings, what should you plant them into?
- There are a number of different hydroponic production systems
- The two that are most well-suited for lettuce and herbs (leafy crops) are:
  1) Nutrient-film technique
  2) Deep-flow technique



Different spacing for nursery channels or different crops



Deep-flow technique (Raft or raceway system)



Deep-flow technique

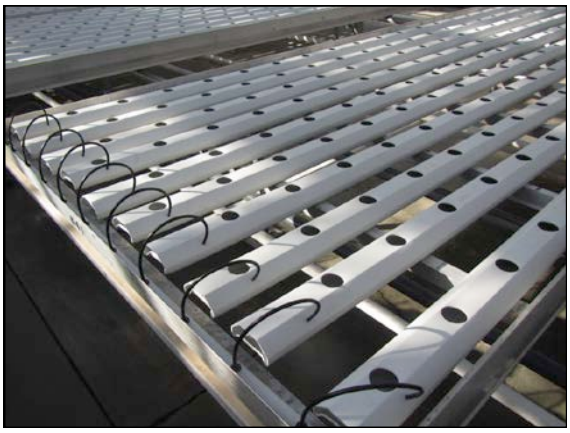
Advantages

- Very high planting density in raft
- High space utilization
- If designed properly, major labor savings
- Water volume is deep (unlike NFT)
  - Pumps breaking down is less of an issue

Disadvantages

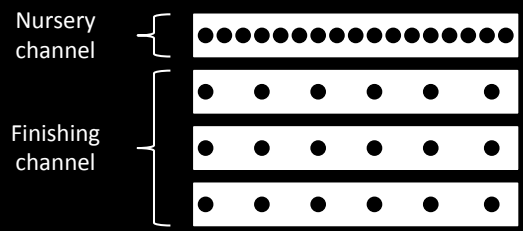
- Oxygen levels in water decrease with time
- Air pumps must be used to increase O2 content of water
- Chilling the nutrient solution can be required during periods of warm temperatures

Nutrient-film technique



Nursery channels may be used to save on space

Young plants at a high density save on space



Nutrient-film technique

Advantages

- The nutrient solution has a higher oxygen content because it is consistently moving
- Troughs can be picked up making harvesting easy
- Troughs can be stacked in more than one layer

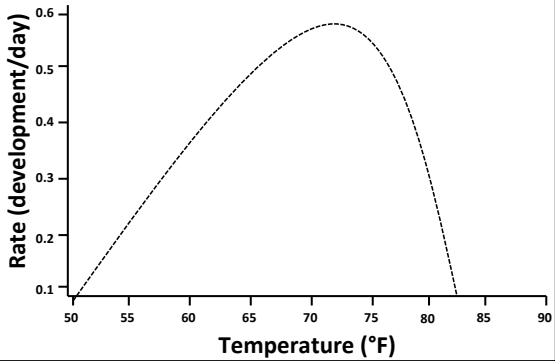
Disadvantages

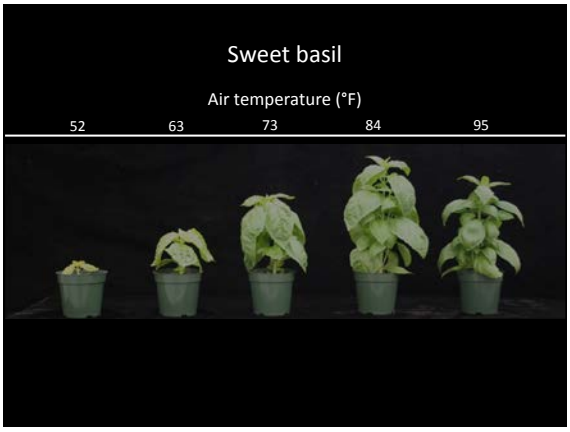
- The number-one problem with NFT systems = A loss of nutrient solution delivery can result in plant death
  - Clogged emitters
  - Pump not functioning

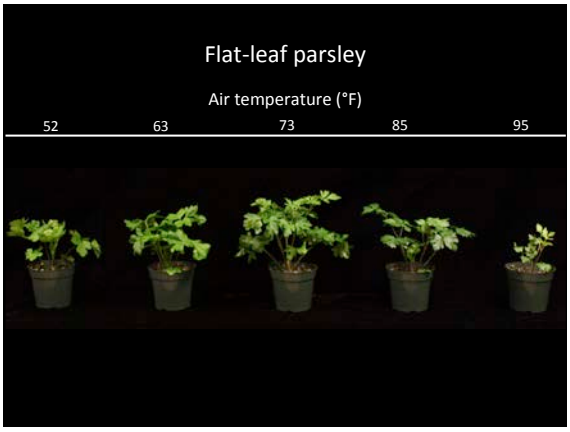
Temperature

- Air temperature controls the rate of growth and development
- Managing your air temperature has a strong impact on the productivity of your crops
- Different crops have different temperature requirements

ADT and development







Target temperatures

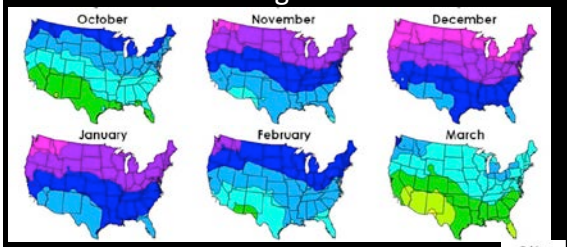
- Lettuce is generally considered a "cool-growing" crop, but air temperature that are too cool can delay maturity
  - Air temperatures from 63 to 68°F are fairly common
- The wide variety among culinary herbs makes it difficult to recommend a specific temperature
  - What herb is produced in the greatest volume?

Air temperature (°F)										
46	50	54	58	62	66	70	74	78	82	86
Parsley										
Chives										
Dill										
			Mint							
			Oregano							
				Cilantro						
					Rosemary					
					Sage					
							Basil			

Light and growth

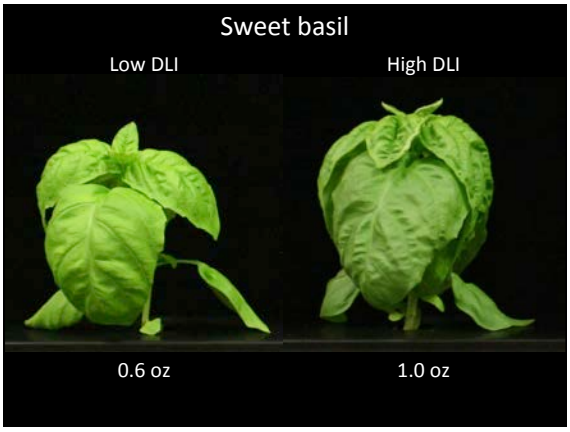
- Light has a large impact on the growth of hydroponic lettuce and herbs
- Growth = weight = $$$
- However, light can become a limiting factor during the summer production season

Light



Light levels change throughout the year, but light is most limiting when greenhouse and controlled-environment crop production has major production advantages- in the winter!

Korczynski et al, 2002

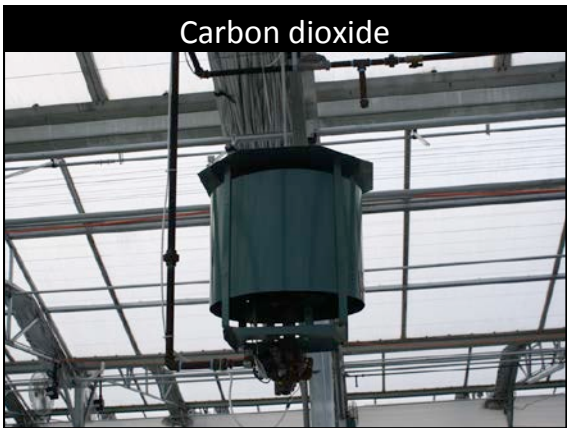


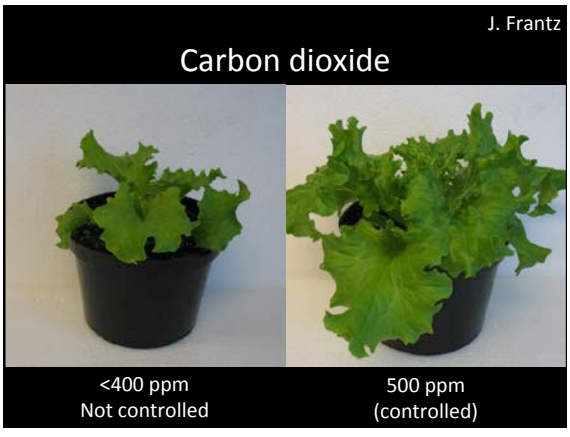
Supplemental light

- The use of supplemental electric light can help boost productivity of your lettuce and herbs
- There are several types of lights that may be used to increase light in a greenhouse
  - High-pressure sodium lamps
  - Light-emitting diodes (LEDs)

Carbon dioxide

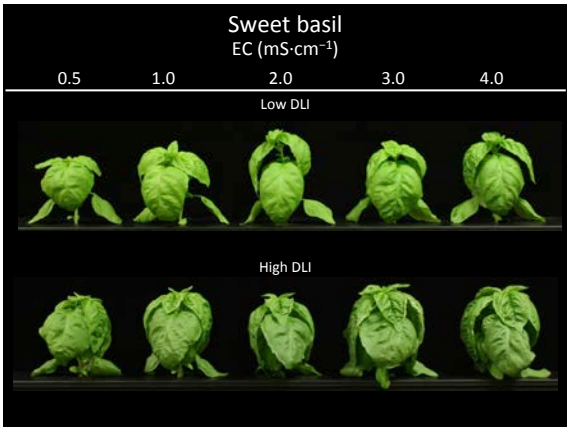
- Carbon dioxide can be depleted in a greenhouse
- Adding supplemental CO_2 can enhance the growth of hydroponic crops
  - Especially in the winter with less venting!
- CO_2 can be added in one of two ways:
  - CO_2 burners
  - Liquid CO_2





Fertilizing Hydroponic Crops

- Hydroponically grown crops require the same macro- and micro-nutrients that containerized crops require
- In hydroponic crop production, the abundance of mineral nutrients is measured as:
  - EC
  - ppm
- A target concentration is maintained by adding stock solution



Mineral nutrients

- There are three primary types of fertilizers:

  1- Single-bag mixes

  2- Two-bag mixes

  3- Individual element mixes

Single-bag mixes

- Single-bag mixes provide all of the required mineral nutrients on one bag
- Very easy to use- just pick the desired concentration and measure out the required amount
- The ratio of elements to one another is fixed

Two-bag fertilizers

- Two-bag mixes are another popular option for fertilizers
- By using two tanks, concentrated stock solutions can be made without elements reacting and precipitating out of solution
  - "A" tank- calcium and iron
  - "B" tank- phosphates and sulfates

A and B tank fertilizer system

Individual compound fertilizers

- Individual components can be used to mix fertilizers
- By using individual compounds to mix fertilizers, growers have ultimate control
- However, this can be time consuming and tedious

Lettuce solution

Element	Concentration (ppm)
Nitrogen	100-200
Phosphorous	15-90
Potassium	80-350
Calcium	122-220
Magnesium	26-96
Boron	0.14-1.5
Copper	0.07-0.1
Iron	4-10
Manganese	0.5-1.0
Molybdenum	0.05-0.06
Zinc	0.5-2.5

Nutrient solution EC

0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8
Mint										
	Sweet basil									
	Parsley									
		Dill								
		Sage								
				Cilantro						
					Opal basil					
							Rosemary			

What is Water Quality?

- Measure of
  - Electrical Conductivity
  - Alkalinity
  - pH
  - Hardness
  - Toxicities

Water Tests

- When to test?
  - Seasonal greenhouse
    - Once at the beginning of the season
  - Year-round greenhouse
    - Dry season
    - Wet season

TEST	RESULTS	NORMAL RANGE
Soluble Salts ms/cm EC	0.05*	0.30 - 1.00
pH	7.84	0.00 - 0.00
ALK ppm CaCO3	23.03	0.00 - 0.00
Calcium ppm Ca	9.57*	40.00 - 75.00
Magnesium ppm Mg	0.87*	30.00 - 50.00
Sodium ppm Na	3.78	0.00 - 50.00
Chloride ppm Cl	20.73	0.00 - 70.00
Boron ppm B	0	0.00 - 0.50
Iron ppm Fe	0	0.00 - 2.00
Manganese ppm Mn	0	0.00 - 1.50
Sulfur ppm S	1.19*	10.00 - 80.00
Copper ppm Cu	0	0.00 - 0.20
Zinc ppm Zn	0	0.00 - 0.40
Molybdenum ppm Mo	0	0.00 - 0.20
Aluminum ppm Al	0	0.00 - 1.00
Nitrate ppm NO3-N	0	0.00 - 10.00
Ammonium ppm NH4-N	0.3	0.00 - 10.00
N ppm Urea	0	0.00 - 10.00
Total Nitrogen ppm TN	0.3	0.00 - 0.00
Phosphorus ppm P	0.65	0.00 - 10.00
Potassium ppm K	2.17	0.00 - 10.00

Electrical Conductivity

- Measure of soluble salts
- Units = mho/cm or mS/cm
- Critical limit -0.3 – 1.0 mS/cm
- High soluble salts can cause
  - Wilting
  - Root tip dieback
  - Leaf necrosis

Some species can tolerate very high EC levels and we may purposely elevate the E.C

pH

- pH is the measure of H+ ions in a solution
  - pH 0-7 = acidic
  - pH 7-14 = basic (alkaline)
- pH effects nutrient availability in the soil solution

What is Alkalinity?

•Alkalinity – the buffering capacity of water to resist change in pH

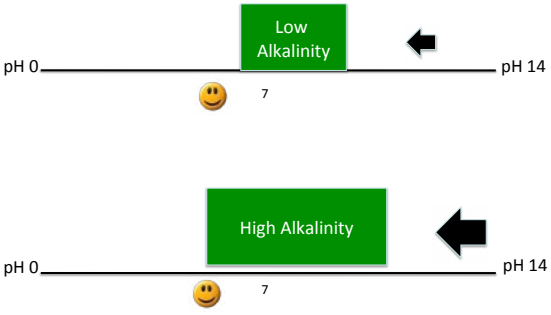
- Carbonate
  - CO_3^{-2}
- Bicarbonate
  - HCO_3^-

What is Water Alkalinity?

Alkalinity

- Units of measure
  - Millieqivilants/Liter
  - PPM
- Convert from meq/L to PPM
  - Carbonate
    - 1 meq/L = 50 ppm
  - Bicarbonate
    - 1 meq/L = 61 ppm

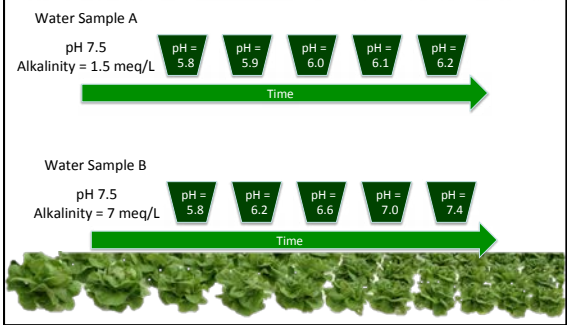
Alkalinity



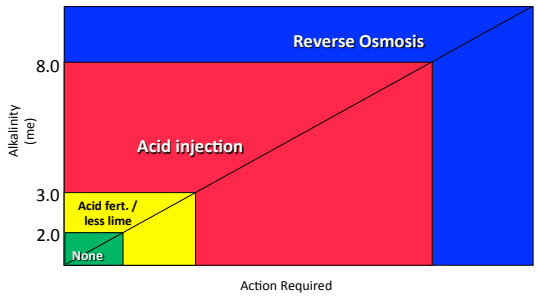
Alkalinity vs pH

Water Sample A	Water Sample B
pH 7.5 Alkalinity = 1.5 meq/L	pH 7.5 Alkalinity = 7 meq/L
Acceptable	Problematic

Alkalinity vs pH



Alkalinity



Alkalinity

- Correction with Acid Injection
  - Nitric Acid
  - Phosphoric Acid
  - Sulfuric Acid**
- Added acid neutralizes alkalinity in water

Using Acid Injection

- Nutrients are added with acid
- Must compensate fertilizer program
  - Sulfuric acid often a preferred acid
- UNH-NCSU AlkCALC
  - www.nhfloriculture.com

Hardness

- Combined content of calcium and magnesium
  - me/L
  - ppm
- Ratio of calcium : magnesium
  - 3-5:1

TEST	RESULTS
Soluble Salts ms/cm EC	0.05*
pH	7.84
ALK ppm CaC03	23.03

TEST	RESULTS
Soluble Salts ms/cm EC	0.05*
pH	7.84
ALK ppm CaC03	23.03
Calcium ppm Ca	9.57*
Magnesium ppm Mg	0.87*

- Ca:Mg
  - 11:1

Excess Ca will block Mg uptake

TEST			RESULTS
Soluble Salts		mmhos/cm	0.75
pH			7.5
Alkalinity		ppm	400.00
Calcium	Ca	ppm	75.19
Magnesium	Mg	ppm	36.95

- Ca:Mg
  - 2:1

Excess Mg will block Ca uptake

TEST	RESULTS
Soluble Salts ms/cm EC	0.06
pH	6.20
ALK ppm CaC03	62.10
Calcium ppm Ca	8.24
Magnesium ppm Mg	2.06

- Ca:Mg
  - 4:1

No imbalance problems

Sodium

- Critical limit = 50 ppm
- Will increase the E.C. of water
- High levels can inhibit uptake of:
  - Potassium
  - Ammonium
  - Calcium
  - Magnesium

Chlorine

- Chlorine – Cl
- Chloride - Cl^-
- Critical limit – 0.4 ppm
- Root-tip burn
- Chlorine reacts with organic matter to convert to chloride
- Aerating or carbon filter will usually remove chlorine

Iron

- Critical limit – 4 ppm
- As little as 0.5 ppm can cause staining due to iron bacteria
- Bacteria can plug equipment

Fluoride

- Added to many municipal water supplies
  - 0.5 – 1 ppm
  - Critical limit 0.5 ppm
- Many lily species and foliage species are sensitive to fluoride

Others

- Manganese – 0.5 ppm
- Zinc – in 0.3 ppm

Safe for irrigation water. Maybe even higher

- Copper – 0.2 ppm
- Boron – 1 ppm

> 1ppm is toxic

What is Water Quality?

- Measure of
  - Electrical Conductivity
  - Alkalinity
  - pH
  - Hardness
  - Toxicities

Now You Know the Answer!

Winter Farmer's Markets

Greens Production

- Why (or why not) to grow in the winter?
- How is winter growing different
- Special considerations for winter
  - Dealing with snow
  - Crop scheduling and management
  - Harvesting
  - Ect.

Greens Production

- Year-round income is nice
- Gaining value from vacant space is nice

But….it's challenging

- Planning winter crops in July, August & Sept
- Dealing with harvest logistics in snow and cold
- Not having a 'Down time"

Food Safety

- Need to rethink our pest management methods
  - Products for ornamentals may not be registered for edibles
    - Fundamental difference from transplants

Food Safety

- FSMA (Food Safety and Modernization Act)
  - Passed in 2011
  - Rules and regulations are in draft form and will go into affect Fall of 2015
  - 1-6 years to come into compliance

FSMA – Food Safety

- Food based illnesses
  - You are liable – have liability insurance
- Talk to your local extension, and regulation folks

FSMA – Food Safety

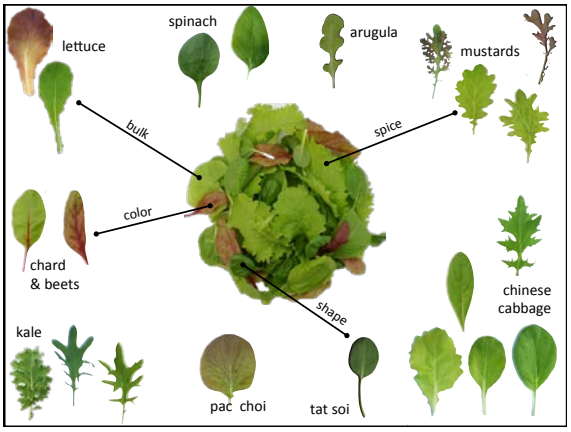
- Keep good records of sales!
- You may not be covered by FSMA
  - <$25,000 in sales of produce
  - <$500,000 in food and ½ is direct marketed

Post-Harvest

- Cleaning
- Perishable Product
  - Immediate market
  - Cold storage

Marketing

- Direct sales
  - Garden Center
  - Farm stand
  - Farmers' market
- Restaurants
- Grocery Stores



Growing Greens In a Nutshell!

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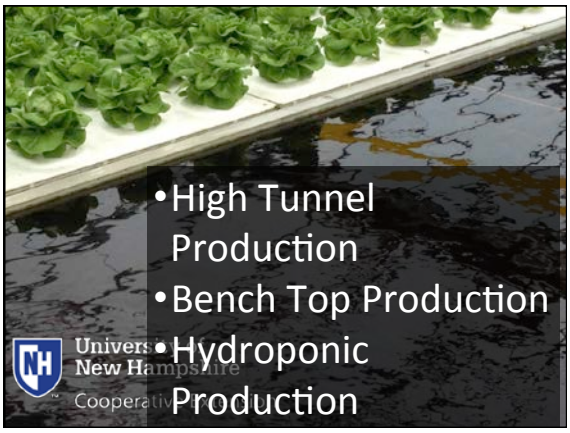


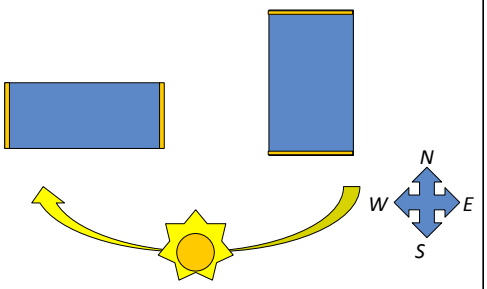
Some tunnels are not designed to withstand snow load. Most will not take heavy, wet snow.

Be prepared.

- *give snow a place to go*
- *have 4x4 braces to support bows*
- *use a broom or mop during snow fall*
- *heat, if possible, to melt snow*
- *as a last resort, cut plastic*

Moveable tunnels allow more use of the tunnel space
But they need to be FIRMLY anchored.

Photo: Eric Sideman



East-West Orientation is better for winter light

Larger greenhouse = lower surface area:volume ratio = less heat loss

Larger (30'x48') Ledgewood tunnel

Using supplemental rowcover can give an additional protection of 10 °F or more…

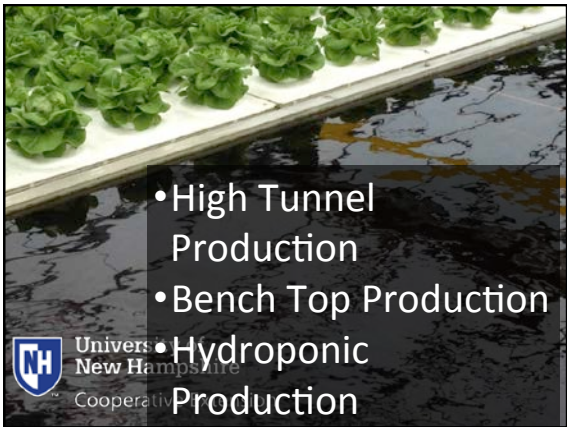
Bench Top Production

January	February	March	April
May	June	July	August
September	October	November	December

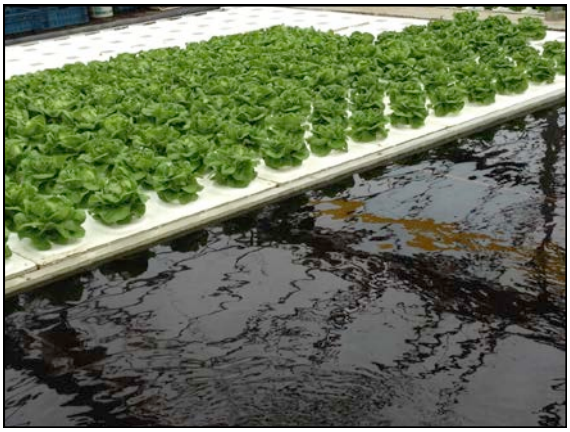
Does it make money?

			Profit
Media	Fort Vee mix Vermont compost	$9.15	-$565
	Peat + Osmocote Start 12-17-11 Germination mix Living Acres compost	$8.26	-$80
		$6.10	$1093

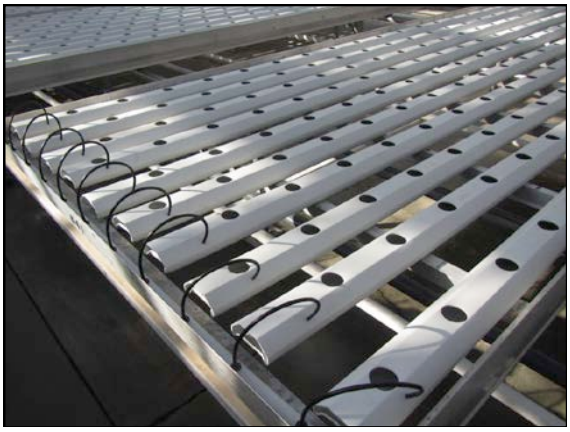
http://extension.unh.edu/Grower-Resources/Research-Reports

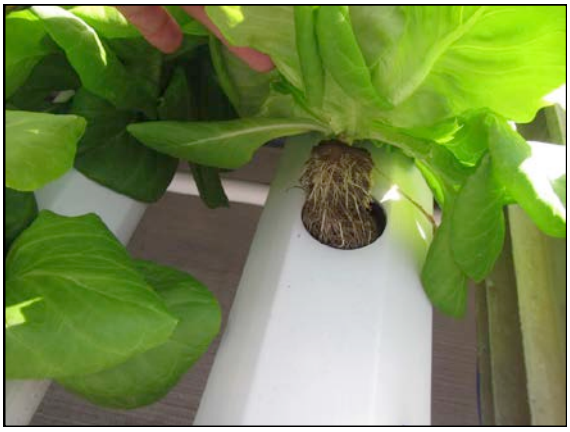



Types of Hydroponic Systems
University of
New Hampshire
Cooperative Extension




Crop King

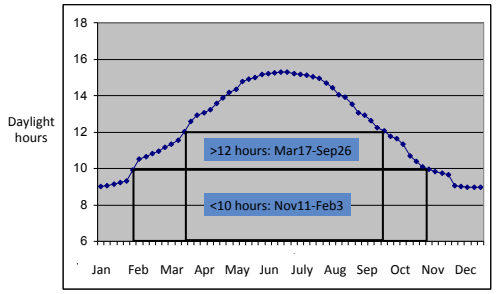





How is Winter Growing Different?
University of New Hampshire
Cooperative Extension

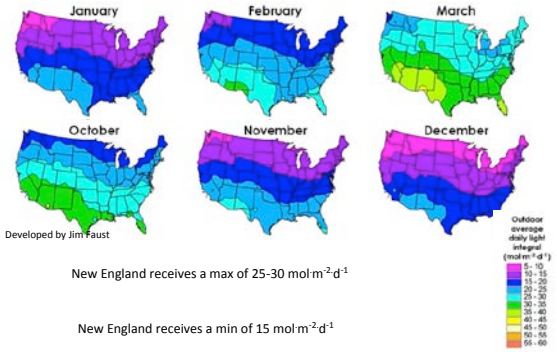

Light is the #1 Problem

There is less light during the winter months



Hours between sunrise-sunset in Plymouth NH

Daily Light Integral



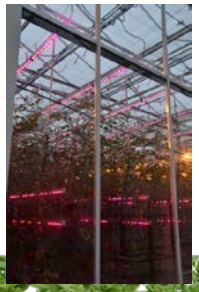
New England receives a max of 25-30 mol·m^{-2}·d^{-1}

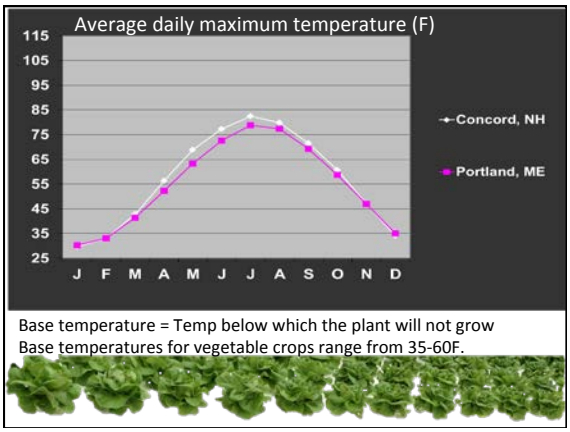
New England receives a min of 15 mol·m^{-2}·d^{-1}

Light is the #1 Problem

- How much light is needed
  - Lettuce needs a minimum of 12 to 14 mol·m^{-2}·d^{-1}
- Greenhouse will reduce the DLI by 40% (6 mols in Dec)
- High-pressure sodium lights (1,200 fc)
  - Lights need to be on 7 to 14 hr/day

Light is the #1 Problem





Base temperature = Temp below which the plant will not grow
Base temperatures for vegetable crops range from 35-60F.

Winter Production

- Plants are damaged by cold temperatures:
  - Freeze damage – broken cells
  - Desiccation – water is lost faster than it is taken up
  - Frost cracks – tissues expand and contract
- Plants vary in hardiness
- Hardy plant acclimate to colder temps
- Plants respond to gradual exposure

Cool Season Crops		Warm Season Crops	
Hardy	**Half-Hardy**	**Tender**	**Very Tender**
Asparagus	Artichoke	Cowpea	Cantaloupe
Chive	Beet	Snap bean	Cucumber
Garlic	Carrot	Edamame	Eggplant
Onion	Cauliflower	Sweet corn	Lima bean
Leek	Celery	Tomato	Okra
Horseradish	Chard		Pepper
Pea	Chinese cabbage		Pumpkin
Rhubarb	Endive		Squash
Spinach	Lettuce		Sweetpotato
MANY Brassicas	Parsnip		Watermelon
	Potato		
40-45F	45-50F	50-60F	60-65F

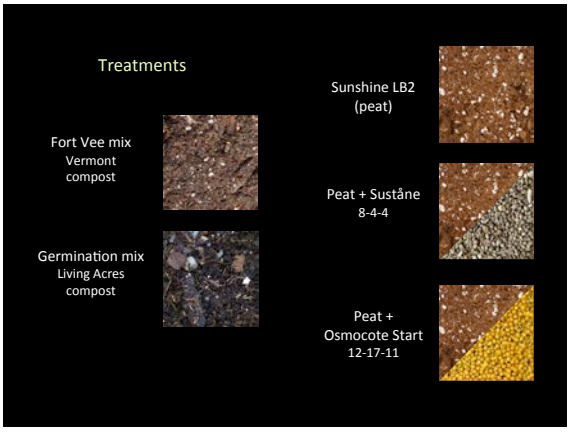
Adapted from Knott's Handbook for Vegetable Growers, 4th Edition

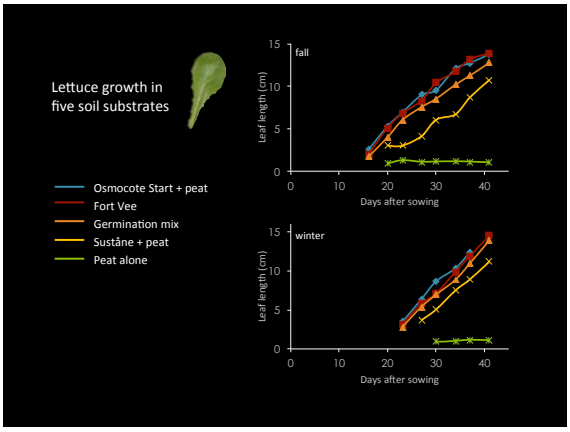
Temperature

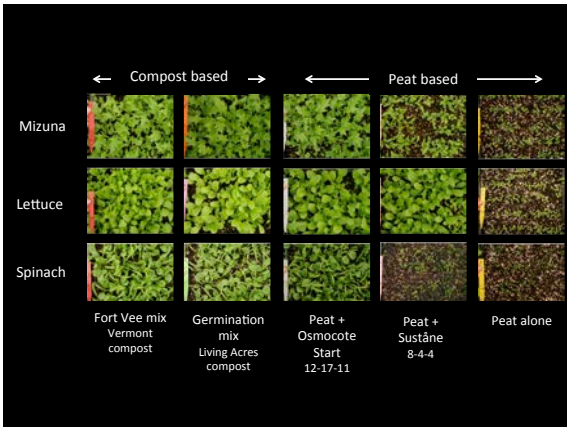
- Increased heat will increase production
- Will heating expense be offset by income?
  - Maybe
  - Maybe not

Fertility

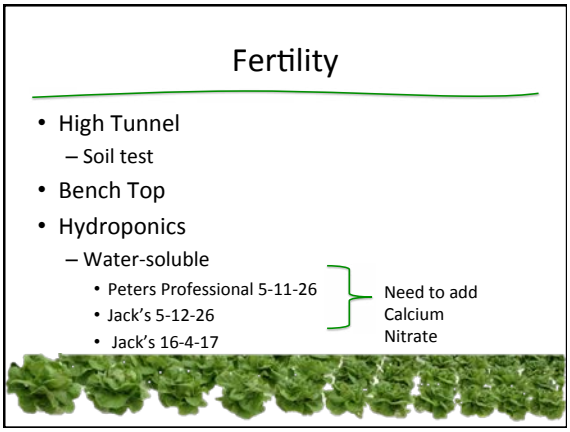
- High Tunnel
  - Soil test
- Bench Top






Compost based
Peat based
Mizuna
Lettuce
Spinach
Fort Vee mix Vermont compost
Germination mix Living Acres compost
Peat + Osmocote Start 12-17-11
Peat + Suståne 8-4-4
Peat alone


Price comparison per cu ft
Fort Vee mix Vermont compost
$9.15
Peat + Osmocote Start 12-17-11
$8.26
Peat + Suståne 8-4-4
$8.01
Sunshine LB2 peat
$7.67
Germination mix Living Acres compost
$6.10


Fertility
• High Tunnel
– Soil test
• Bench Top
• Hydroponics
– Water-soluble
• Peters Professional 5-11-26
• Jack's 5-12-26
• Jack's 16-4-17
Need to add Calcium Nitrate