PURDUE EXTENSION | LOCAL FACES COUNTLESS CONNECTIONS

BASICS OF HYDROPONIC CROP PRODUCTION

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STATISTICS

STATISTICS – Indiana and surrounding states

Abbreviations and Symbols

(Z) Less than half of the unit shown
(D) Withheld to avoid disclosing data for individual operations

Horticulture Specialties Census: 2014 Food Crops Grown Under Protection and Sold (Acres)	U.S.	Michigan	Ohio	Illinois	Indiana	Kentucky
Total	**2142**	**25**	**24**	**11**	**12**	**13**
Cucumbers	252	10	1	0.3	0.2	1
Herbs, cut fresh	318	1	2	(Z)	1	0
Lettuce, all	99	1	5	0.2	2	1
Peppers, all	81	1	1	0.4	(D)	0
Strawberries	14	0	0	0.2	(D)	1
Tomatoes	978	6	10	7	8	9
Other food crops	399	5	6	3	(D)	1

STATISTICS – Indiana

Horticulture Specialties Census: **2014** **Food Crops Grown Under Protection and Sold**	Production % from hydroponics	Value of sales % wholesale	 % retail
Total: U.S.	**63.4**	**76.1**	**23.9**
Total: Indiana	11.5	64.4	35.6
Herbs, cut fresh	20.9	99.4	0.6
Lettuce, all	56.9	-	-
Tomatoes	5.5	41.7	58.3

Abbreviations and Symbols

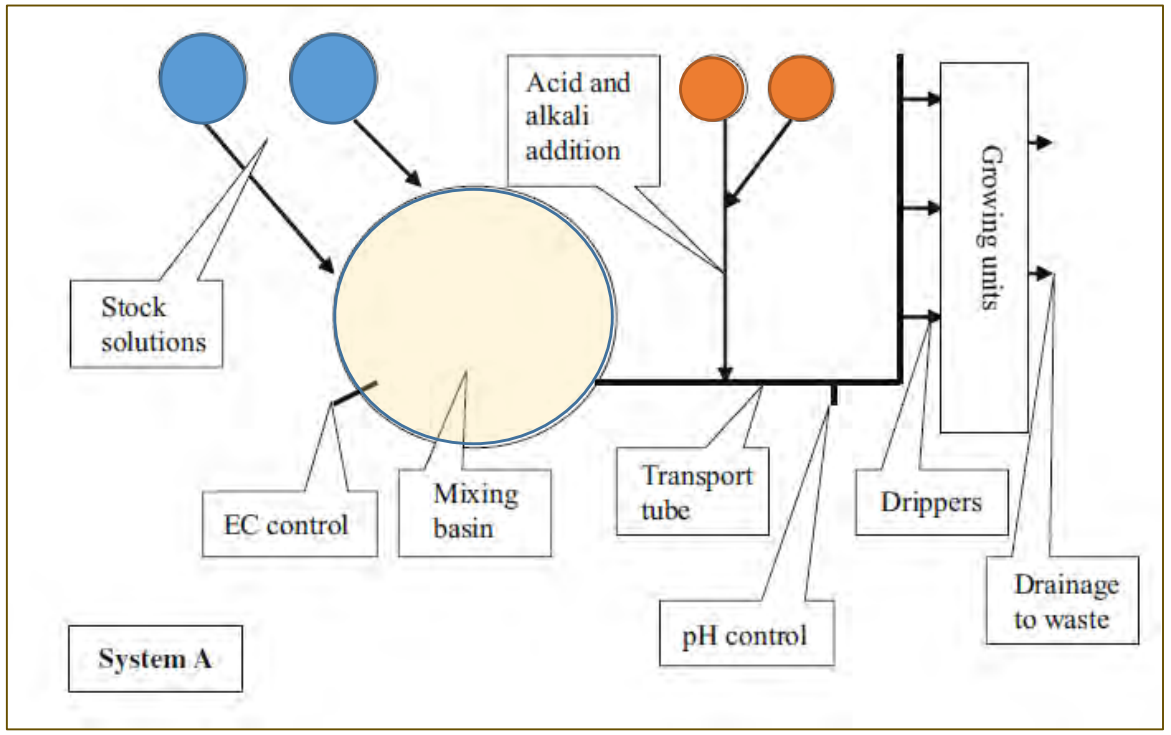
(-) No information available

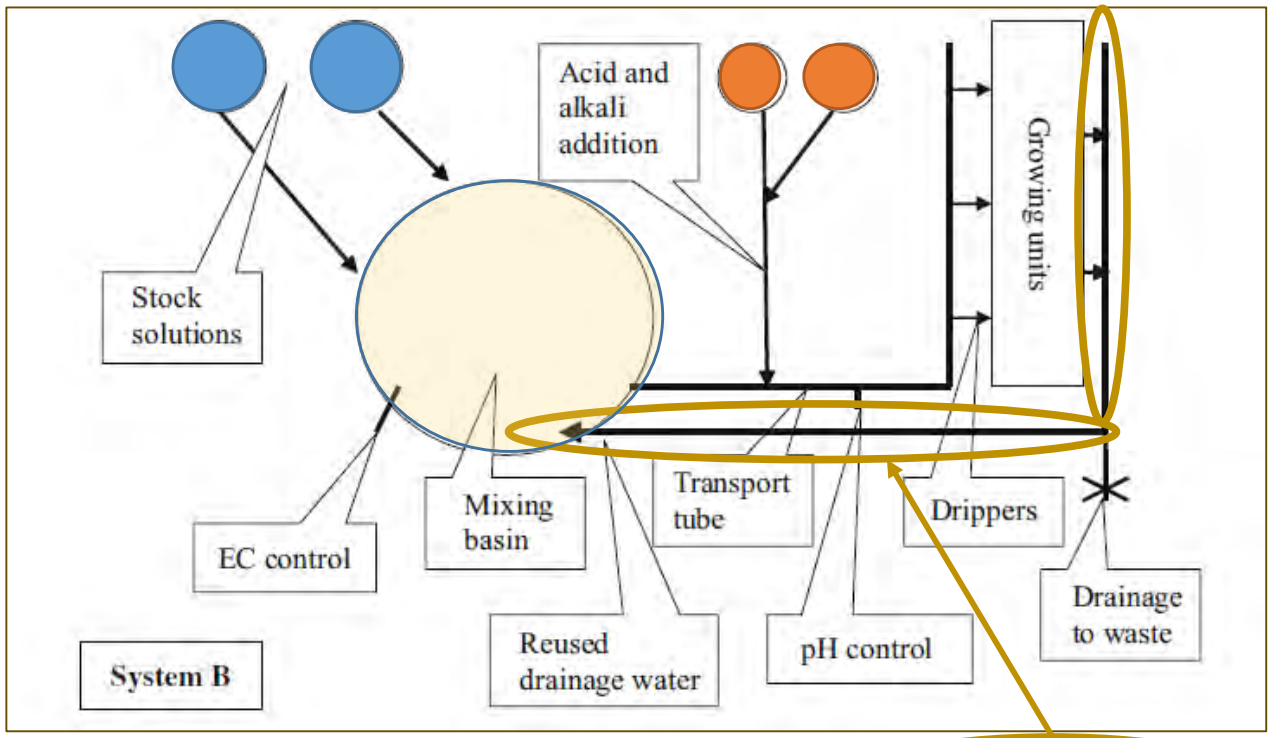
SOILLESS PRODUCTION

HYDROPONICS

- The word **hydroponics** technically means working water, stemming from the Latin words "hydro" **meaning** water, and "ponos" **meaning** labor.
- **Hydroponics** is a subset of hydroculture and is a method of growing plants using mineral nutrient solutions, in water, without soil.
- Two types of hydroponics, solution culture and medium culture.
- **Solution culture types** (only solution for roots)
  - **Continuous flow solution culture, Nutrient Film Technique (Dr Alan Cooper, 1960's)**
  - **Aeroponics**
- **Medium culture types** (solid medium for roots, sub- or top irrigated, and in a container)
  - **Ebb and Flow (or flood and drain) sub-irrigation**
  - **Run to waste (drain to waste)**
  - **Deep water culture**, plant roots suspended in nutrient solution
  - Passive sub-irrigation, inert porous medium transports water and nutrients by capillary action. Pot sits in shallow solution or on a capillary mat saturated with nutrient solution.

SOILLESS PRODUCTION, key system features





Run to waste

Recycling

Disinfection: slow sand filtration / UV

Source: Plant nutrition of greenhouse crops. C. Sonneveld and W. Voogt, 2009.

SOLUTION CULTURE

NUTRIENT FILM TECHNIQUE

- Recirculating cultivation system
- Continuous flow of nutrient solution past roots
- Shallow stream (film) of water containing all dissolved nutrients is recirculated past the bare roots of plants in a watertight, dark channel.
- Roots develop at bottom of channel allowing for an abundant supply of oxygen to the roots.
- Slope of 1:100 recommended, but 1:30 and 1:40 are also used
- As general guide the flow rate is 1 L (0.26 gal.) per minute with an upper limit of 2 L (0.53 gal) per minute
- Channel length should not exceed 10-15 meters (33-49 ft.)
- Operator have to pay close attention to nutrient balances, water temperature and pathogens

NUTRIENT FILM TECHNIQUE, fixed channel

Photo: CROP*KING*

Photo: hydrocentre.com.au

NUNTRIENT FILM TECHNIQUE, mobile channel system

Watch video, MGS by Hortiplan
www.hortamericas.com

Photos curtesy of Karlovec Media Group
Facility of Great Lakes Growers, Burton, Ohio

INDOOR VERTICAL FARMS, growing with supplemental LED's

Photos: Green Sense Farms

GREEN SENSE FARMS
Watch us grow

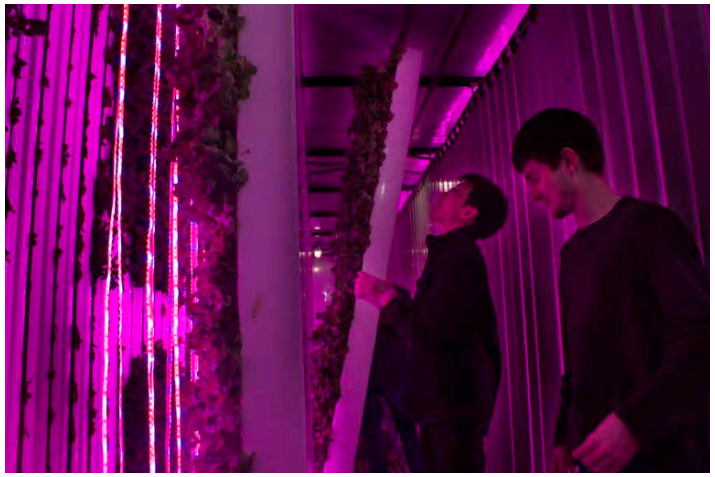
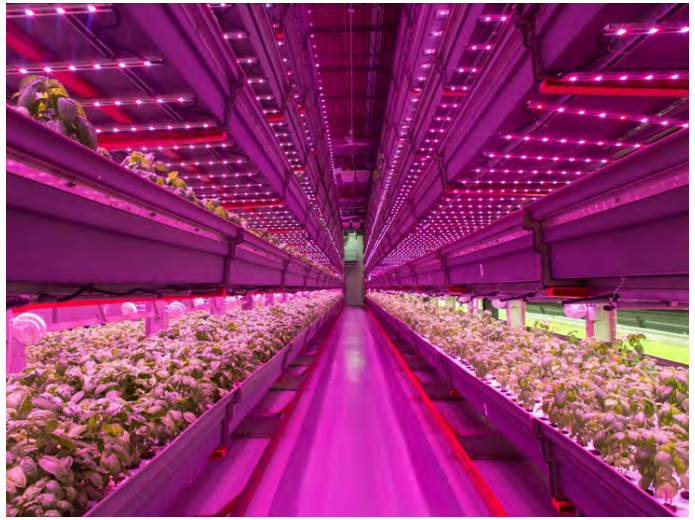


Photo: Freight Farms

Photos: Growtainer

Photos: FarmedHere



farmed here
sustainable indoor farming

AQUA PONICS

DEEP WATER CULTURE (DEEP FLOW), vegetable seedling production

Without seedling trays

With seedling trays

Photos: Petrus Langenhoven

VARIATION: GRAVEL FLOW TECHNIQUE, home gardener

Photos: Petrus Langenhoven

AEROPONICS, recirculating cultivation system

Roots are continuously or discontinuously kept in an environment saturated with a mist or aerosol of nutrient solution

Anthurium flower production

Potato seed production

5-10 times more seed than potted systems, International Potato Center (CIP)

Potato Photos: Neiker-Tecnalia
http://www.basqueresearch.com/new/2172

MEDIUM CULTURE

EBB AND FLOW, recirculating cultivation system

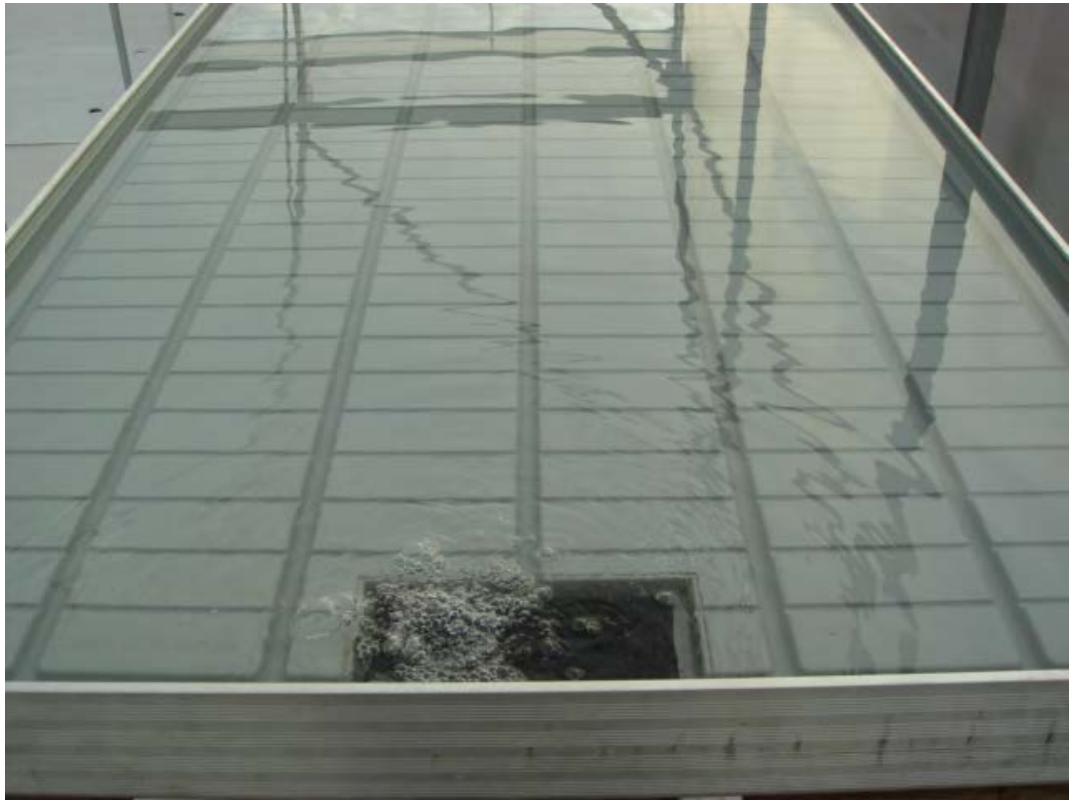


Photo: Petrus Langenhoven

EBB AND FLOW, recirculating cultivation system - Heartland Growers, Westfield IN



Photos: Petrus Langenhoven

RUN TO WASTE (drain to waste), container with substrate, irrigated individually

Photos: Petrus Langenhoven

RUN TO WASTE (drain to waste), high tunnel

Photos: Petrus Langenhoven

RECIRCULATING, soil grown (Belgium)

Photos: Petrus Langenhoven

RECIRCULATING, Rockwool slabs with 4 plants per slab

Photos: Petrus Langenhoven

POPULAR AGGREGATES/SUBSTRATES

Inorganic Media		Organic Media
Natural	Synthetic	
Sand	Foam mats	Sawdust
Gravel	(Polyurethane)	Bark (Pine)
Rockwool	Polystyrene Foam	Wood chips
Glasswool	"Oasis"	**Peat moss**
Perlite	(Plastic Foam)	**Coir**
Vermiculite	Hydrogel	(Coconut fiber)
Pumice	**Biostrate Felt®**	**Rice Hulls**
Expanded Clay	(Biobased Product)	
Zeolite		
Volcanic Tuff		

Photos: Petrus Langenhoven

CROPS

HYDROPONIC lettuce and basil

Photo: Petrus Langenhoven

Photo: Rutgers Univ. EcoComplex

TOMATO AND CUCUMBER in soilless substrate

Photos: Petrus Langenhoven

PRODUCTION OF ALTERNATIVE HIGH VALUE PRODUCTS
(examples of baby squash)






Photos: Petrus Langenhoven

MELONS – Vertically trellised in a high tunnel or greenhouse

Photos: Petrus Langenhoven

CROP: BASIL - Who is my customer?

Organic, Soil-grown herbs

Hand-picked herbs grown in soilless substrate

Photos: Petrus Langenhoven

Potted living herbs grown in soilless substrate

Photo: Kitchen Pick Living herbs

Photo: Petrus Langenhoven

IRRIGATION WATER

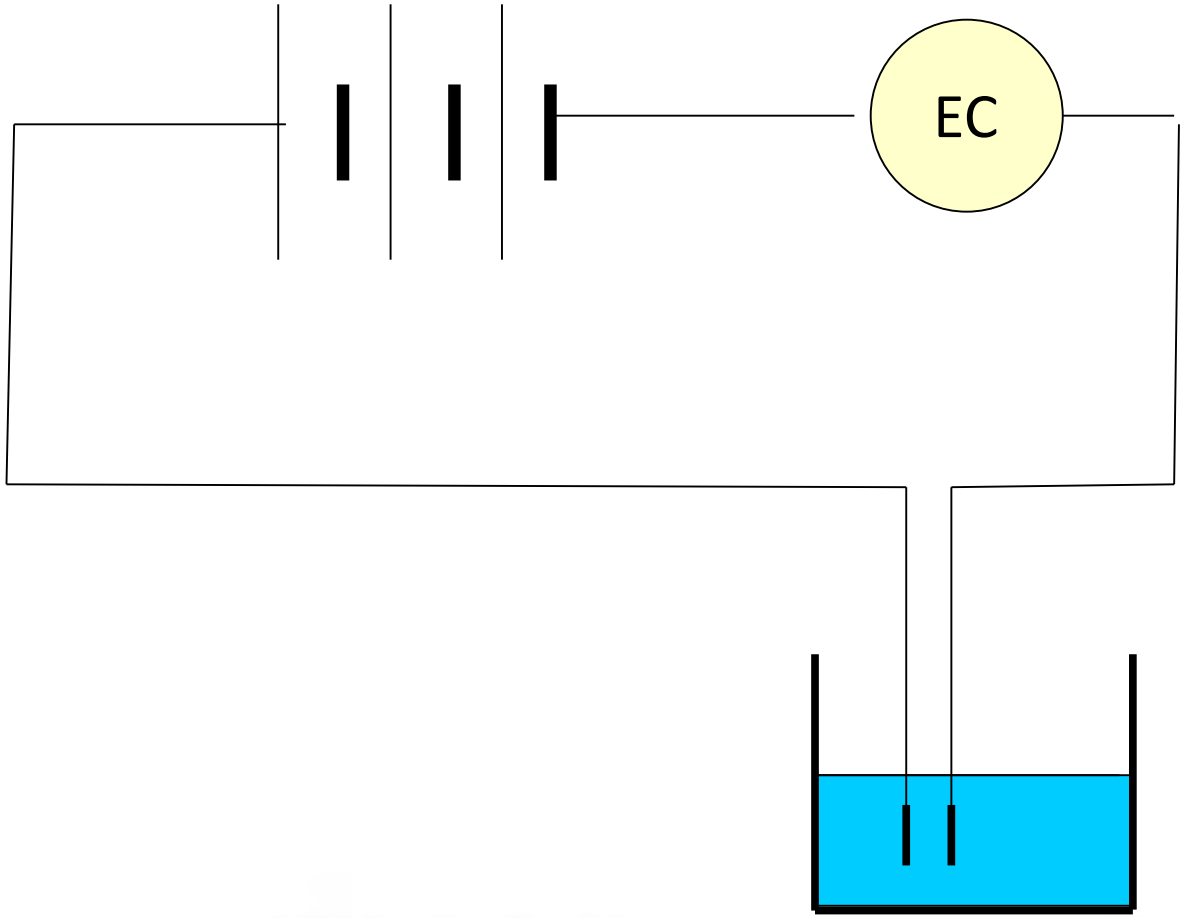
INTERPRETING IRRIGATION WATER TESTS

Parameter	Level of concern	Notes
EC	Above 1.5 $dS \cdot m^{-1}$	Accumulation of specific salt which reduce crop growth
pH	Below 5.4 or above 7.0	
Total Alkalinity (as $CaCO_3$), acid-buffering capacity	Below 30 ppm or above 100 ppm	pH 5.2, 40 ppm alkalinity; pH 5.8, 80 ppm alkalinity; pH 6.2, 120 ppm alkalinity
Hardness (amount of dissolved Ca and Mg)	Below 50 ppm or above 150 ppm	Equipment clogging and foliar staining problems above 150 ppm
Bicarbonate (HCO_3^-)	Above 122 ppm	Increased pH and can lead to Ca and Mg carbonate precipitation
Chloride	Above 30 ppm for sensitive plants; above 70 ppm for most plants	Revers osmosis
Sodium	Above 50 ppm	Reverse osmosis
Sulfate	Above 90 ppm	High concentrations can lead to build-up of sulfur-bacteria in irrigation lines that could clog emitters
Boron	Above 0.5 ppm	
Iron	>0.3 ppm, clogging; 1.0 ppm, foliar spotting and clogging; above 5.0 ppm, toxic	Could lead to iron precipitates resulting in plugging of irrigation system emitters

Photos: Petrus Langenhoven

Nutrient solution

Electrical conductivity (EC), affected by the concentration and valence of ions



Units may be confusing!

1 mmho cm^{-1}

1 dS m^{-1}

1 mS cm^{-1}

10 mS dm^{-1}

100 mS m^{-1}

1000 µS cm^{-1}

EC readings of a 2 $mS \cdot cm^{-1}$ solution, affected by temperature

Temp (°F)	Temp (°C)	EC ($mS\ cm^{-1}$)
59	15	1.62
68	20	1.80
77	**25**	**2.00**
86	30	2.20

pH range of 5.2-6.5 for optimal nutrient availability

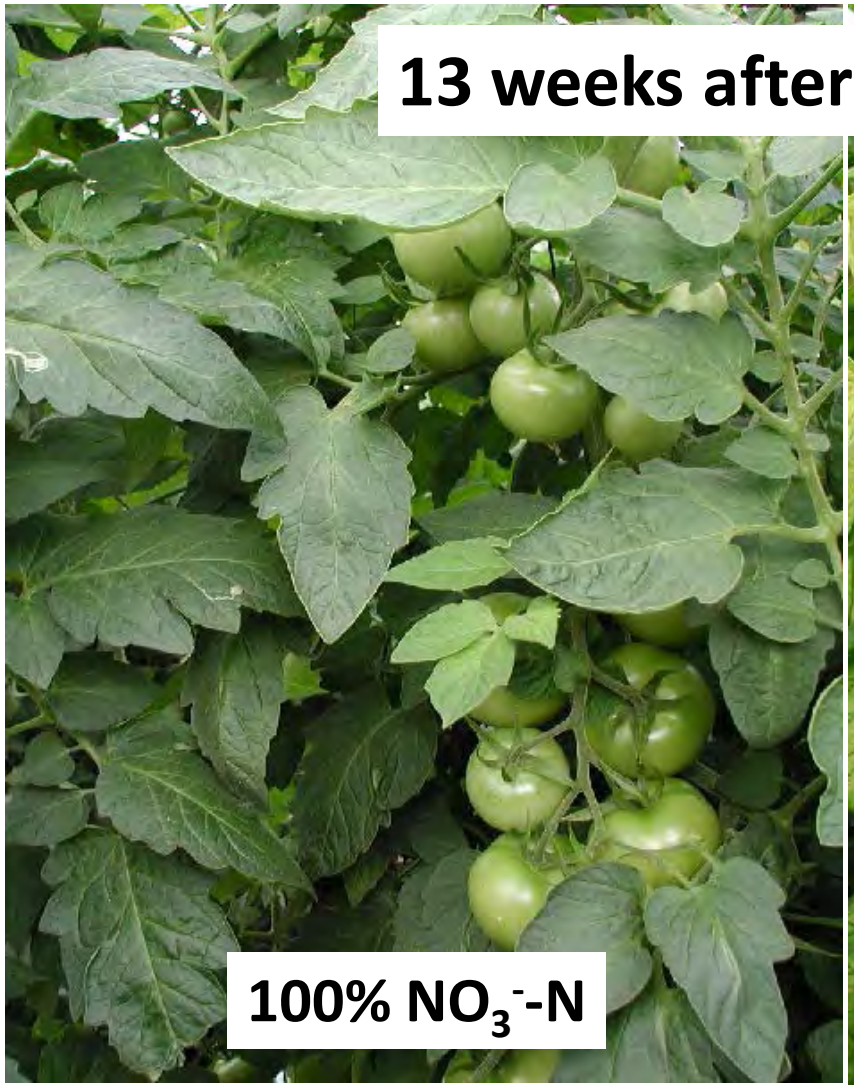
Source: www.taiwanhydroponics.com

MACRO NUTRIENT DEFFICIENCIES

- http://www.haifa-group.com/knowledge_center/crop_guides/tomato/plant_nutrition/nutrient_deficiency_symptoms/

NUTRIENT IMBALANCES

Photos: Petrus Langenhoven



FERTILIZER AND NUTRIENT SOLUTION MIXING TIPS

- Use **high quality ingredients** for your nutrient solution
- If using mixed fertilizer, make sure the blend has a tag that shows the **analysis of the fertilizer**, the source used and company's name
- Do **accurate calculations** and use accurate scales
- **Lukewarm water** will speed up the time for dissolution of the fertilizer
- **Stir** while mixing the fertilizer, mechanical or by hand
- Make sure **compatible fertilizer** are mixed in the same tank. Insoluble precipitates will form when mixed in concentrated form
- **Calcium phosphate**, from calcium nitrate and phosphorus materials; **calcium sulfate**, from mixing calcium nitrate and magnesium sulfate
- **Two-tank system**: calcium, iron and potassium nitrate in one tank and the rest in the other tank
- Keep solution in a **dark environment**

Photos: Petrus Langenhoven

HIGH TUNNELS AND GREENHOUSES

HIGH TUNNELS

High tunnels are low-cost, passive, solar greenhouses which use no fossil fuels for heating or venting. High tunnels can provide many benefits to horticulture crop producers:

- **Modify growing environment** for crop earliness
- **Protect the growing crop** from environmental stress such as driving rain, wind, hail, extreme light intensity, and temperature extremes
- **Reduction** of insect and disease pressure
- Well suited for **producing** specialty crops, which require a specific growing environment
- Permit **intensive crop production** on a small area of land
- Possible Uses
  - Are used to **extend the growing and harvest season** of warm season vegetable crops, both in spring (starting in February) and fall (continuing through November); tomato, pepper etc.
  - **Winter harvesting** for cool season vegetables; baby salad greens, spinach, carrot, beet, leek, etc.
  - **High value specialty crop** protection; small fruit, cut flowers, potted plants, etc.

GREENHOUSES

The terms greenhouse, high tunnel, hoop house and cold frame are sometimes used interchangeably.

By definition, a **greenhouse has a heat source other than solar energy**

- To **optimize plant growth** the greenhouse **climate is controlled** by computer and equipment i.e. circulation and extraction fans, screens, lighting, heating, cooling etc.
- Structure can be **covered by two layers of polyethylene film**, with an electric inflation fan keeping the two layers separate for better insulation
- **Other glazing materials** such as polycarbonate and glass can be used
- Focus is usually on **soilless production** systems, but production in the soil is also popular

Photo: Wikipedia.org

RELIABLE INFORMATION SOURCES

- Professional magazines
  - Greenhouse Grower, www.greenhousegrower.com
  - Practical Hydroponics and Greenhouses, www.hydroponics.com.au
  - Greenhouse Canada, www.greenhousecanada.com
- Books
  - Greenhouse Technology and management, Nicolas Castilla
  - Greenhouse Operation and Management, Paul V. Nelson
  - Soilless Culture, Michael Raviv & J. Heinrich Leith
  - Growing Media for Ornamental Plants and Turf, Kevin Handreck & Niel Black
  - Plant Nutrition of Greenhouse Crops, Cees Sonneveld & Wim Voogt
  - Hydroponic Food Production, Howard M. Resh
- Trade shows and conferences
  - Aquaponics Conference, October 28-29, 2016 – Kokomo IN
  - Great Lakes Fruit, Vegetable and Farm Market EXPO, Dec 6-8, 2016 – Grand Rapids MI
  - Indiana Horticulture Congress, January 10-12, 2017 – Indianapolis IN
  - Indiana Small Farm Conference, March 2-4, 2017 – Danville IN
  - Indoor Ag Con, May 3-4, 2017 – Las Vegas NV
  - Cultivate'17, July 15-18, 2017 – Columbus OH
- University resources

THANK YOU

Questions?

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