UNIVERSITY OF ILLINOIS EXTENSION

PREPARING A NEW GENERATION
OF ILLINOIS FRUIT AND VEGETABLE FARMERS

HYDROPONIC PRODUCTION

Jeff Kindhart

September 2015

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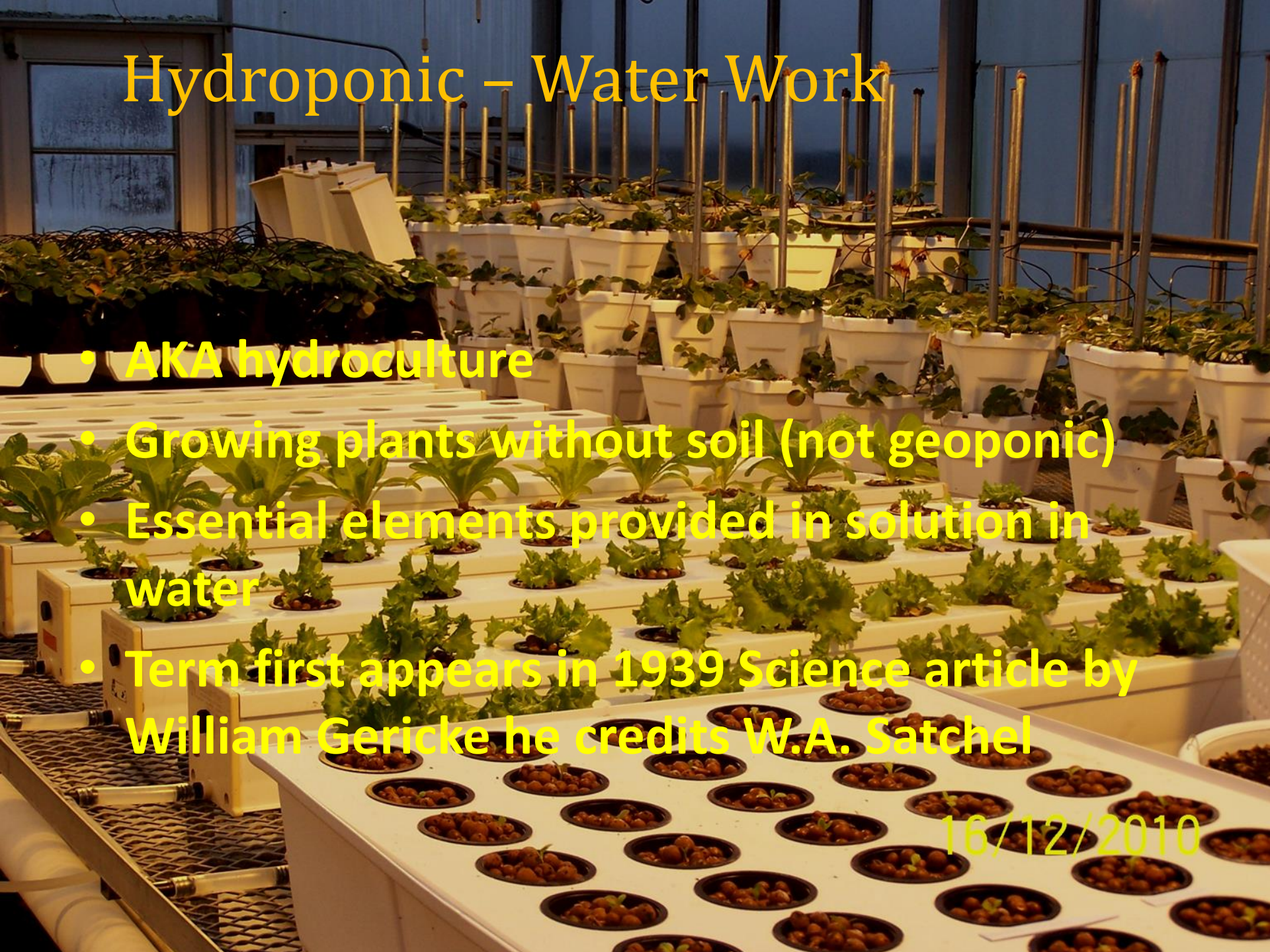
Hydroponic – Water Work



- AKA hydroculture
- Growing plants without soil (not geoponic)
- Essential elements provided in solution in water
- Term first appears in 1939 Science article by William Gericke he credits W.A. Satchel

16/12/2010

Why ?

- Stable yields
- Rapid crop development
- Avoid soil borne pathogens
- Allows crop production where there is no soil or contaminated soil (roof tops, abandoned buildings)
- Lower bulk density of common substrates makes this method a better choice for vertical growing
- Food Safety?????

Disadvantages

- No or little buffering no power or no water = Disaster
- Requires a much higher level of management
- Expense (equipment and supplies and labor)
- Difficult to conduct organically

History

Ancient gardens of Babylon ???

Being done in 1600's but with minimal understanding

Francis Bacon & others

1937 William Gericke – UC – coined term (credited Satchel) and promoted system

1938 UC's Dennis Hoagland and Daniel Amon publish bulletin "The Water Culture Method for Growing Plants Without Soil"

1940's Used on Pacific rim islands (soilless atolls) for food production

1960's NFT

1980's Epcot Center

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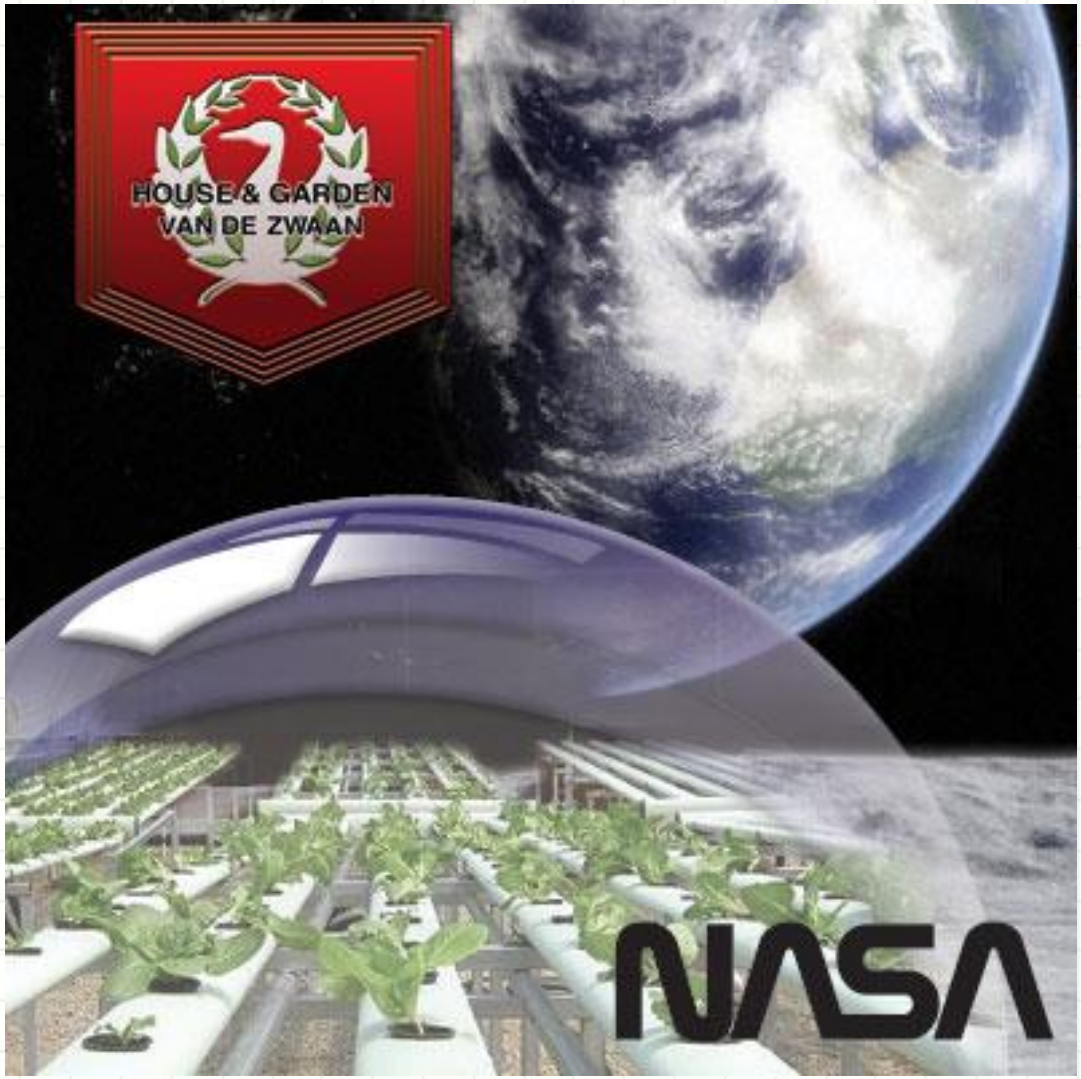
CELLS – Controlled Ecological Life Support Systems



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Types

- Static

- Intermittent flow

- Continuous flow

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The Deluxe 3.0

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Hydroponics for urban food production

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Hydroponic production systems

- Water culture
  - Floating raft
  - Aeroponics
- Nutrient film technique
- Ebb-and-flow
- Soilless media culture
  - Rockwool
  - Vermiculite
  - Perlite
  - Coco coir

Floating raft systems

- Roots are continuously saturated in water
- Seedlings started in soilless media and transplanted into rafts
- Requirements:
  - Root aeration
  - Root darkness (avoid algae growth)
  - Plant support

Floating raft systems

- Benefits:
  - Low cost and maintenance
  - Rafts can be maneuvered through the bed
  - Popular in aquaponic systems
- Drawbacks:
  - Root disease

    (*Pythium* spp.)

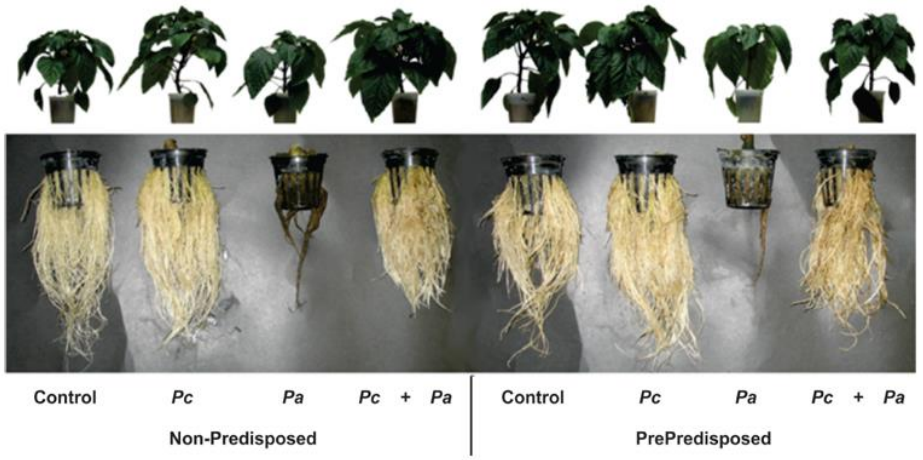
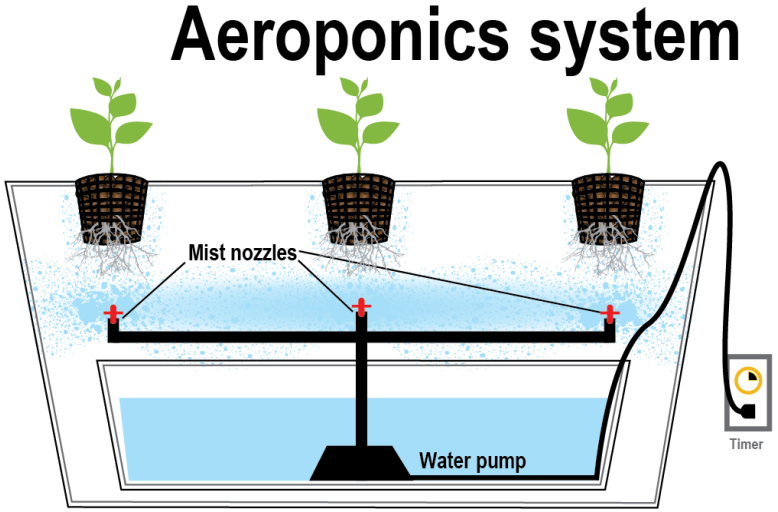


FIGURE 3 - Pictorial comparison of the effects of *Pseudomonas chlororaphis* 63-28 (*Pc*) and inoculation of the roots with *Pythium aphanidermatum* (*Pa*), separately and in combination, in pepper plants that were not predisposed or predisposed to Pythium root rot. Plants were photographed at nine days after inoculation with *Pa*. *Pc* was applied in the nutrient solution 10 days before the roots were inoculated with *Pa*. The root zone of non-predisposed plants was maintained at 23°C and the temperature was increased to 33˚C for three days prior to inoculation with *Pa* for predisposing the plants.

Aeroponic systems

- Roots are bathed in a nutrient mist
- Popular for plant physiology studies, less common commercially
- A-frames and vertical columns possible

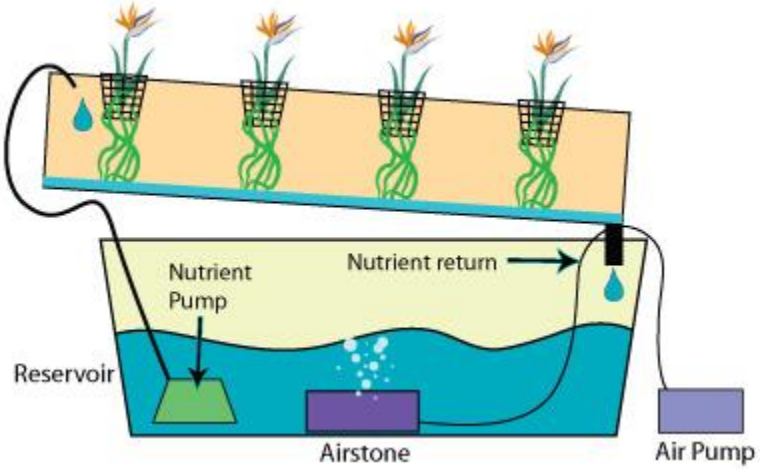


Aeroponic systems

- Benefits:
  - Provides sufficient oxygen, minimizes disease
  - Used for growing root crops hydroponically (e.g., seed potatoes and medicinal roots)
- Drawbacks:
  - Energy intensive

Nutrient film technique

- Similar to floating raft
- Nutrient solution continuously circulates/passes through bottom of root zone
- Nutrient solution is gravity-fed through troughs and pumped back to supply line



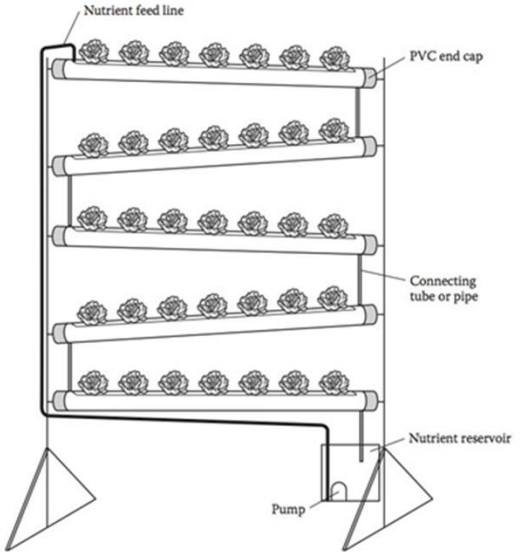


FIGURE 6.3 Details of a "cascade" NFT system. (Courtesy of George Barile, Accurate Art, Inc., Holbrook, NY.)

Nutrient film technique

- Benefits:
  - Improved oxygenation of roots
  - Can construct from home gutters
- Drawbacks:
  - Troughs can get clogged by root mass, water level rises, oxygen level decrease
  - Most suitable for short-term crops (lettuce, herbs)

Ebb-and-flow systems

- a.k.a. flood-and-drain systems
- Essentially sub-irrigation
- Tables or trays are flooded intermittently
- Flood tables have trenches to allow for complete drainage

Ebb-and-flow systems

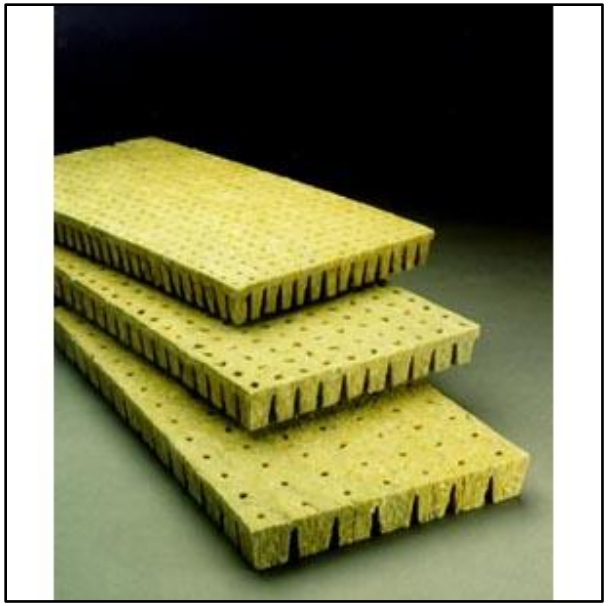
- Benefits:
  - Popular for potted ornamentals
  - Roots are well oxygenated
- Drawbacks:
  - Plant can become stressed during “ebb” phase
  - Frequency and duration of flooding depends on growing media and crop

Soilless culture systems - Rockwool

- Stone wool made from basalt (lava rock), heated to 1,500°C, spun into threads, and cooled (1 m^3 basalt = 90 m^3 stone wool)
- 95% pore space, 80% water-holding capacity
- Slightly alkaline, but no buffering capacity

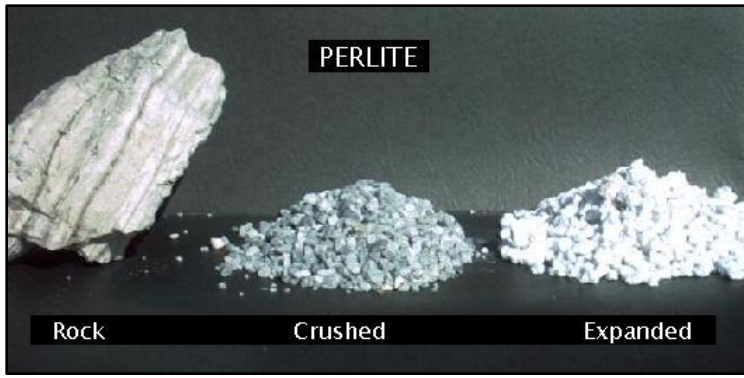
Rockwool

- Come in varying sizes to accommodate germination through maturity
- 5,000 acres of greenhouse crops grown in rockwool in the Netherlands
- Drawbacks:
  - Not biodegradable, though Grodan offers recycling



Soilless culture systems - perlite

- Silica mineral mined from lava flows, heated to 760°C forming small, spongy, sterile, lightweight kernels
- Hold 3-4x weight in water
- No buffering or CEC capacity
- No nutrient value
- Rigid structure good for aeration



Soilless culture systems – vermiculite

- Mica mineral that expands at 1,100°C forming porous, spongy, sterile kernels
- Light weight and high water holding capacity
- Unlike rockwool and perlite, has high CEC (contains some plant available Mg and K)

Soilless culture systems – coco coir

- Ground-up coconut palm husks
- Good air capacity, capillarity, and moisture retention
- pH 6 with high CEC (from lignin and cellulose)
- Coir pith (part of the fiber) is a dust that can be converted into a hydroponic medium

Benefits of coco coir

- A potentially sustainable, renewable resource
  - Though coconuts are coming from SE Asia
  - Could be recycled as a soil amendment
- Many growers switching from rockwool
- In theory, coco can be inoculated with beneficial microbes

Hydroponics vs. aquaponics?

- Aquaponics = aquaculture + hydroponics
- Fish effluent is used as fertilizer for plants, and plants filter water for fish
- Microbes convert ammonia to nitrate

Aquaponics solution is typically about 5-40% dilute compared to ideal hydroponic conditions

Sample ID SWEETWATER GREEN HO
Labnum 2096849 Add'l

IRRIGATION WATER ANALYSIS

ELEMENT Method Units	SODIUM EPA 200.7 ppm	CALCIUM EPA 200.7 ppm	MAGNESIUM EPA 200.7 ppm	pH EPA 150.1 ppm	NITRATE NITROGEN EPA 300.0 ppm	SULFATE EPA 300.0 ppm	CONDUCTIVITY EPA 120.1 mmhos/cm	TOTAL DISSOLVED SOLIDS EST. FROM COND ppm	SODIUM ABSORPTION RATIO (SAR) CALCULATION	PHOSPHORUS EPA 200.7 ppm	POTASSIUM EPA 200.7 ppm	BICARBONATE SM 2320 B ppm	CHLORIDE EPA 300.0 ppm	BORON EPA 200.7 ppm
LEVEL FOUND	24.3	81.0	44.6	7.36	58	77	0.840	546	0.5	6.3	19.5	111	32	0.08

Hoagland's solution…

N = 210 ppm
P = 31 ppm
K = 235
Ca = 200
S = 64
Mg = 48
B = 0.5

Hydroponics vs. aquaponics: which crops make sense?

Plants can survive in aquaponic solution…

But can they thrive???

Most advocates of aquaponics suggest 90% of the profit is in the vegetables…

What is in Illinois?

- Ebb and Flow – mostly ornamental
- Gutter systems
- Bag Culture
- Bato Buckets (dutch buckets)
- Vertical Systems

Gutter Systems

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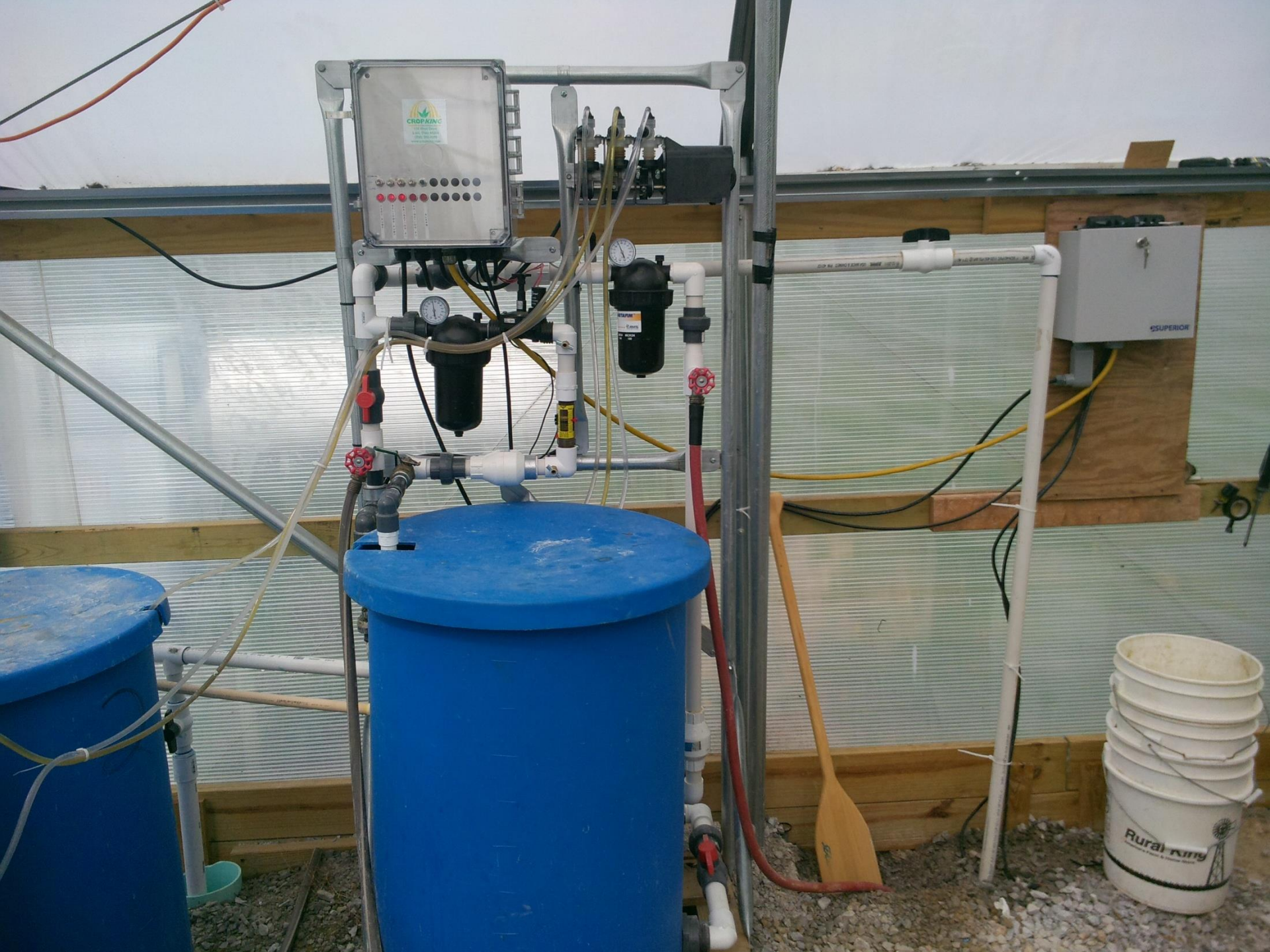
18/11/2010


02/03/2012


CROP KING
SUPERIOR
Rural King


04/09/2004

pH and EC

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DRAIN WASTE AND VENT


27/03/2012

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102.2 °F
OUT
IN 96.8 °F
BY LA CROSSE TECHNOLOGY
in/out
min/max
02/09/2011


04/09/2004


04/09/2004


04/09/2004


05/03/2012


625
28/06/2012

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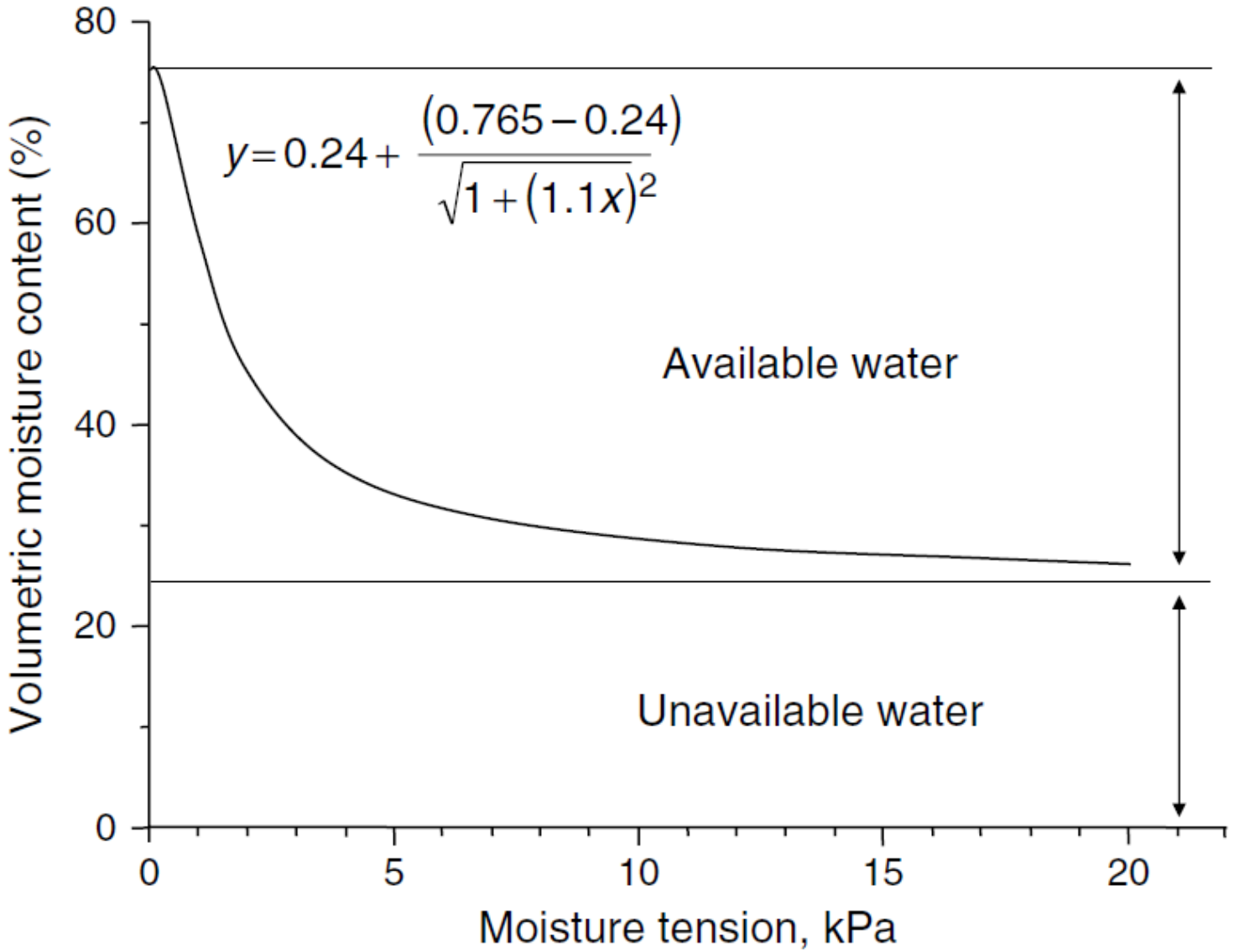
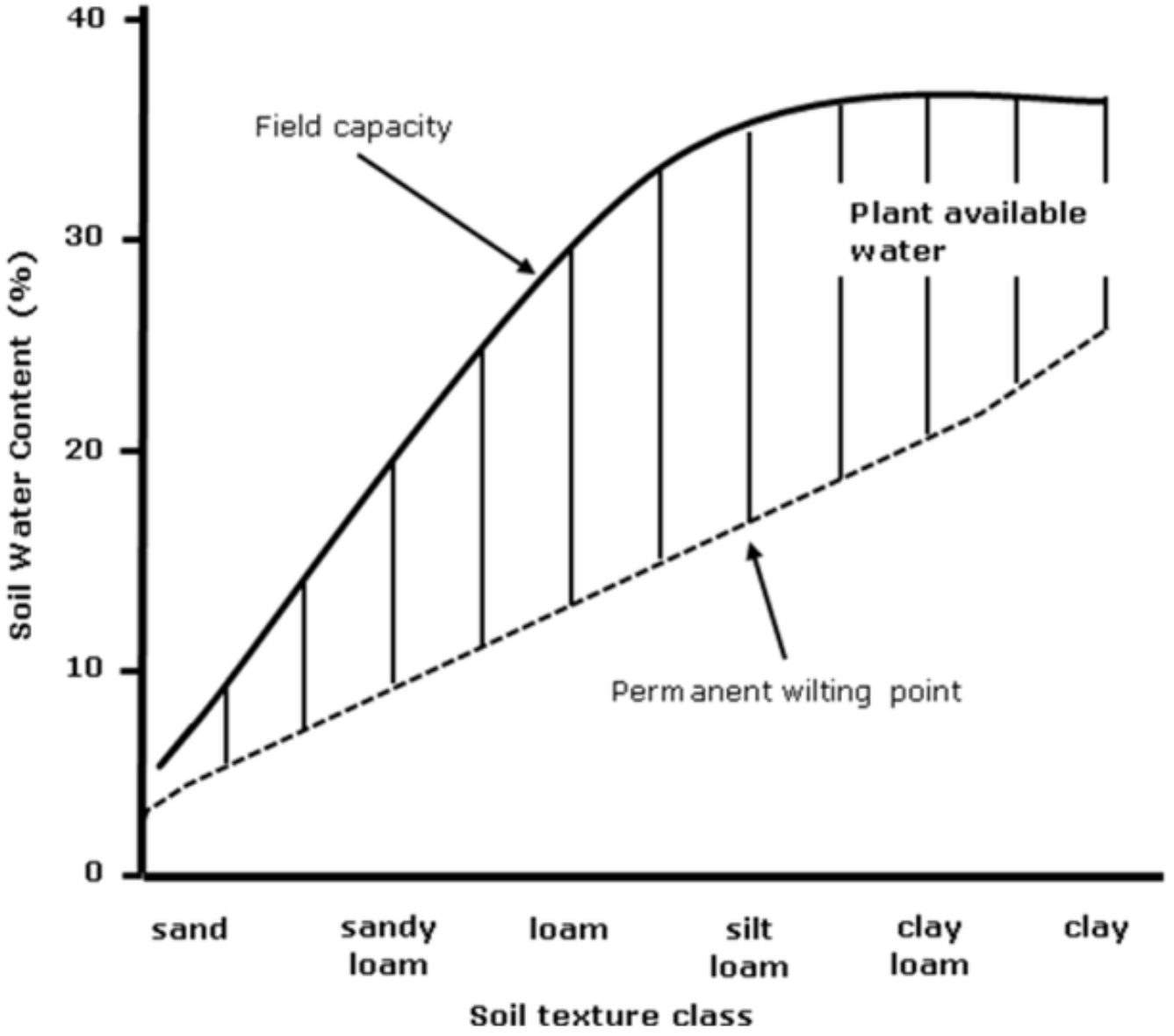
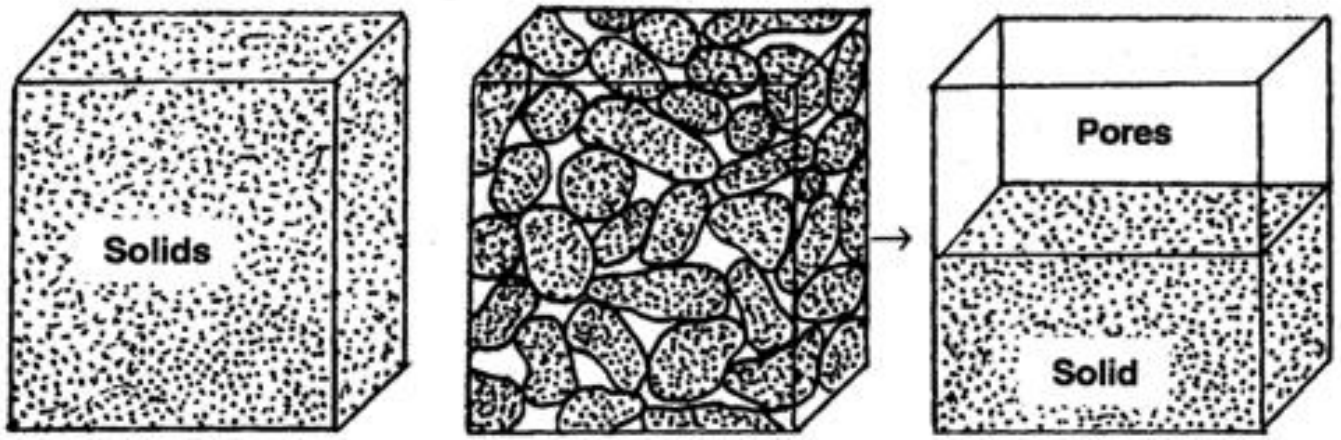
MASSADA
MASSADA


Seeded 11/20
Planted 12/11
Picked 3/18 – 6/25
Yield 34.2 pounds 71 fruit
ARBASON

19.2 pounds 46 fruit


80
60
40
20
0
Volumetric moisture content (%)
$y = 0.24 + \frac{(0.765 - 0.24)}{\sqrt{1 + (1.1x)^2}}$
Available water
Unavailable water
0
5
10
15
20
Moisture tension, kPa





Particle Density

100% solid
Weight = 2.66 g
Volume = 1 cm^3

Bulk Density

50% solid, 50% pore space
Weight = 1.33 g
Volume = 1 cm^3

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