# Vegan Farming Using Controlled Environment Agriculture

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# About the Presenter

- Affiliations
  - CEO, e3garden
  - Associate Professor of Management Science and Information Systems at Penn State Great Valley School of Graduate and Professional Studies
  - Former Director New Ventures and Entrepreneurship option, MBA Program, PSU-Great Valley
- Areas of expertise
  - Entrepreneurship
  - Corporate innovation and strategy
  - Energy policy and sustainability
  - Information Technology
  - Urban Farming and Hydroponics
- Experience
  - Consultant to business and industry
  - Local leader in town government

## Professionally: Why I'm Interested in food production

- We need to localize food production
  - Urban farms make sense
- We need to design food production systems that are sustainable in the use of water, land, energy and nutrients
- We need to avoid the use of pesticides

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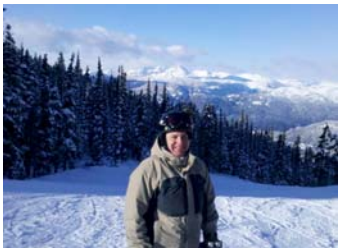
## Personally: Why I'm Interested in food production

- I'm a foodie
  - My wife and I buy organic or pesticide-free foods
  - I like harvesting food from my backyard
  - My wife is Vegan
  - In addition to plants, I eat fish and eggs (certified humanely raised)
- I believe in sustainable food production
- I am a solar-pv producer
- I love to design systems
- I love the outdoors



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# Outline


1. Plant Needs
2. Farm Production Methods Compared
3. Why e3garden is Friendly to Vegans, Locavores, Organics Lovers
4. Summary and Conclusions

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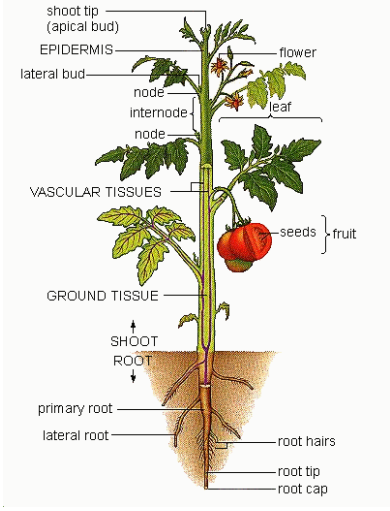
# Plant Needs

# Plant Needs

- Seed
- Medium
- Water
- Light
- Nutrients

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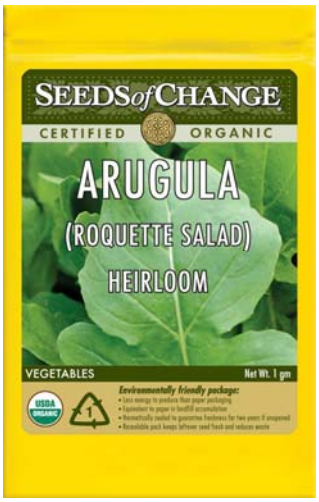
http://www.uic.edu/classes/bios/bios100/lectf03am/lect18.htm

# Seed

- Quality seeds are a critical input
- Buy new seed about every 1-2 years
- These can be conventional, organic, non-GMO
  - Look for USDA or non-GMO seal

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# Germination and Support Media

- Organic Media
  - Soil
  - Compost
- Inorganic Media
  - Coconut Fiber
  - Expanded Clay
  - Perlite
  - Rockwool
  - Sand
  - Vermiculite




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# Water

- Tap water or rain water may be used
  - Must be clean and free of pathogens
  - Traces of chorine in tap water are OK
  - Avoid very hard water
  - If in doubt, have water tested

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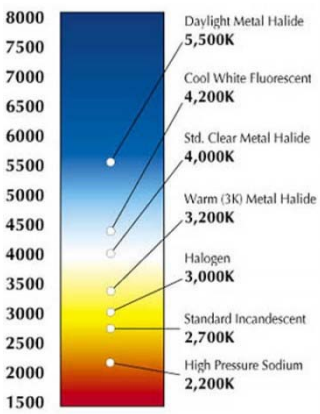
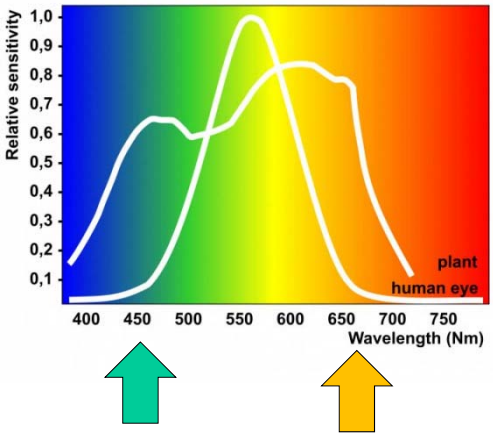
# Light and Plants




Leaf Production Fruit/flower Production 11

# Plant Nutrient Requirements

- **16 Nutrients**
- **Essential Elements**
  - Carbon, Hydrogen and Oxygen
- **Macronutrients**
  - Nutrients needed for plant growth
- **Micronutrients**
  - Essential for plant growth but in smaller quantities

# Primary Macronutrients

- **Nitrogen (N)**
  - Largest quantities
  - Most noticeable and quickest effect on plants
  - Leaf growth and dark green leaves
- **Phosphorus (P)**
  - Strong root systems, more beautiful flowers and rapid growth
- **Potassium (K)**
  - Produces and matures the seed
  - Improves fruit keeping quality
  - Decreases water requirement

NPK

# Secondary Macronutrients

- Needed in smaller quantities than primary macronutrients
  - **Calcium (Ca)** – Promotes root formation
  - **Sulfur (S)** – Promotes root growth
  - **Magnesium (Mg)** – Affects the intake of plant nutrients

# Micronutrients

- Essential for plant growth but needed in very small quantities
- Helps plants absorb and use other available nutrients to complete their biological functions

- Iron (Fe)
- Boron (B)
- Manganese (Mn)
- Molybdenum (Mo)
- Zinc (Zn)
- Chloride (Cl)
- Copper (Cu)

# Key Nutrients for Plants

**TABLE 2.1**
**Elements Essential for Most Higher Plants**

| Element | Symbol | Available Form | Atomic Weight | Parts per Million (ppm) | Concentration in Dry Tissue (%) |
|---|---|---|---|---|---|
| **Macronutrients** | | | | | |
| Hydrogen | H | $H_2O$ | 1.01 | 60,000 | 6 |
| Carbon | C | $CO_2$ | 12.01 | 450,000 | 45 |
| Oxygen | O | $O_2$, $H_2O$ | 16.00 | 450,000 | 45 |
| Nitrogen | N | $NO_3^-$, $NH_4^+$ | 14.01 | 15,000 | 1.5 |
| Potassium | K | $K^+$ | 39.10 | 10,000 | 1.0 |
| Calcium | Ca | $Ca^{2+}$ | 40.08 | 5,000 | 0.5 |
| Magnesium | Mg | $Mg^{2+}$ | 24.32 | 2,000 | 0.2 |
| Phosphorus | P | $H_2PO_4^-$, $HPO_4^{2-}$ | 30.98 | 2,000 | 0.2 |
| Sulfur | S | $SO_4^{2-}$ | 32.07 | 1,000 | 0.1 |
| **Micronutrients** | | | | | |
| Chlorine | Cl | $Cl^-$ | 35.46 | 100 | 0.01 |
| Iron | Fe | $Fe^{3+}$, $Fe^{2+}$ | 55.85 | 100 | 0.01 |
| Manganese | Mn | $Mn^{2+}$ | 54.94 | 50 | 0.005 |
| Boron | B | $BO_3^{2-}$, $B_4O_7^{2-}$ | 10.82 | 20 | 0.002 |
| Zinc | Zn | $Zn^{2+}$ | 65.38 | 20 | 0.002 |
| Copper | Cu | $Cu^{2+}$, $Cu^+$ | 63.54 | 6 | 0.0006 |
| Molybdenum | Mo | $MoO_4^{2-}$ | 95.96 | 0.1 | 0.00001 |

*Source:* Modified from Stout P.R., *Proc. of the 9th Ann. Calif. Fert. Conf.* 1961. pp. 21–23.

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Source: H. Resh, "Hydroponic Food Production", CRC Press, Boca Raton, FL, 2013, p. 10

## Sources of Nutrients

- Animal Waste
- Plants
- Minerals and Salts

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## The Pros and Cons of Farm Production Methods

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# Farm Production Methods

- Open Field
  - Conventional
  - Organic
  - Veganic
- Controlled Environment Agriculture
  - Greenhouses
  - Hydroponic Systems

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# Open Field Production

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# Problems with Conventional and Organic Open Field Farms

- Farms usually have animals
- Manure is often used as compost especially on organic farms
- It costs more to use plant fertilizer, esp. if there is easy access to animal fertilizer
- Synthetic fertilizers can be used but can have negative impacts on the environment
- Uses lots of water
- Tends to require use of pesticides to maintain production levels

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# Veganic Open Field Farming

- Principles
  - Veganic agriculture is an approach to growing plants that includes respect for animals, the environment, health.
  - Also known as "stockfree" "vegan organic" and "plant-based"…
  - (Recommends)... eliminating the use of products that are derived from confined animals. (http://www.goveganic.net/article19.html)
- Challenges
  - Finding vegan farms
  - Water use and run-off
  - Pest management

# CEA and Hydroponic Production

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# CEA Defined

- *"Controlled Environment Agriculture (CEA) is an advanced and intensive form of hydroponically-based agriculture.*
- *Plants are grown within a controlled environment so that horticultural practices can be optimized."*

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http://www.generalhydroponics.com/blog/2011/07/19/hydroponics-in-history-part-1-ancient-hydroponics/

# What is Hydroponics?

- The Greek word “hydro” means water and “ponos” means labor or work.
- Hydroponics is a method of growing plants in water without soil
  - The water must be enriched with nutrients and the plants need an inert medium to support root system
- Hydroponics is a form of CEA
  - CEA = Controlled Environment Agriculture
- Practiced by the ancient Egyptians, Babylonians and Aztecs

http://www.generalhydroponics.com/blog/2011/07/19/hydroponics-in-history-part-1-ancient-hydroponics/

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# Advantages of CEA Farms

- Excellent crops
- Uses much less water
  - As little as 10%!
- Can be grown with no pesticides or herbicides
- Much less labor
  - E.g., weeding, thinning, etc.
- Can grow year-round
- No run-off into eco-systems
- Consistent with the farm-to-table movement, organics, locavore
- It can be Vegan-Friendly!
  - No farm animals
- Projects can promote community development, entrepreneurship, training, research and education

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# Comparison of Different Farms

| | CEA (e3garden) | Veganic Open Field | Organic Open Field | Conventional Open Field |
|---|---|---|---|---|
| No Pesticides | X | X | X | problem |
| Uses less water | X | problem | problem | problem |
| Organic non-GMO Seed | X | x | X | problem |
| Animal-based Fertilizer | | | X | X |
| Plant-based Fertilizer | | X | x | |
| Mineral-based Fertilizer | X | | | x |
| Soilless media | X | | | |
| Soil-based media | | X | X | X |
| Prevents excess fertilizer run-off into eco-system | X | problem | problem | problem |

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# Why e3garden is Friendly to Locavores, Vegans, and Organic Lovers

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## e3garden's Mission

- e3garden's mission is to produce fresh, great tasting vegetables using the least amount of energy and water.
- We are committed to being a triple bottom line company.

- **Edibles**
- **Energy**
- **Education**

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## e3garden's Practices

- We grow our produce from organic seed in controlled environments without the use of pesticides
- We conserve water and protect the environment from outputs
- Our farm is fueled with solar and renewable energy
- e3garden uses no animal products in the production of its vegetables, herbs and microgreens


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# e3garden's Products

- CSA and Market
  - Lettuces
  - Herbs
  - Microgreens

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# e3garden Awards and Partnerships

- We have received 3 USDA grants for sustainability:
  - Energy Efficiency
  - Renewable Energy
  - Value-Added Production for Local and Organic Markets
- We are working in partnership with Philips Lighting Company on the use of horticultural LED's

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# e3garden's People

- Eric Stein
  - CEO and Founder
- Hourly employees
- Interns
  - Ila Outerbridge
  - Temple University Hort Student
- My wife Anne
- Her Mom
- My Clients


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# e3garden's Production


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# Organic Seed

- We start with USDA Organic Certified and non-GMO Seeds
- We buy new seed every year

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# Water

- e3garden uses municipal drinking water
- Closed-loop recirculating system
  - Uses only 10% of water used in open field farming
  - We filter out small particles and algae

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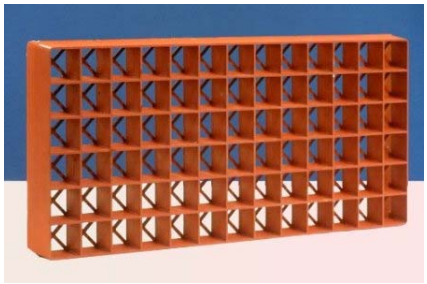
# Germination

- Organic seeds are germinated directly in Rockwool and covered with a dome for 7-10 days
- Rockwool is kept saturated



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# Rockwool Medium

- Rockwool is made from rock which has been melted and spun into fibrous cubes
- Rockwool is one of the most effective media for germinating seeds
- Rockwool's primary benefit is that it transports *both water and oxygen* to plants

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# Seedling Development and Transport

- When 1-2 sets of mature leaves form, plant is transported into floating raft system
- Half strength nutrient values are used to minimize shock to plant

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# Plant Nutrients

- We use water soluble nutrients made from minerals, compounds and salts
- No animal products are used in production of the nutrients
- The nutrients dissolve in water
- Plants take up the nutrients as needed
- Very little nutrient used:
  - Only 5-10 grams per gallon of water
  - Example: 20 gallon tank will feed 100 plants with about 150 grams of nutrient = *5-6 oz per week*
  - *= to 10 tablespoons per week of nutrient*

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# Lighting

- Light is critical to plant development and required for our indoor systems
- We use efficient T5's florescent lights
- Our newest system uses super-efficient LED's optimized for plant growth

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# Mature Lettuce in Channel

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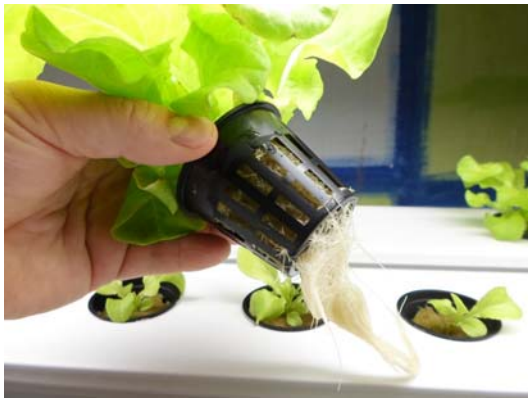
# Root Development



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# The Farm

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# Indoor Production

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# Next Steps

# Next Steps

- We are applying to have our products be Vegan Certified by the American Vegetarian Association (AVA)
- We will be adding solar power to the roof of the garage greenhouse
- We are expanding our microgreen line of products

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# Summary and Conclusions

- CEA farming offers new opportunities to produce vegetables from organic seed that are free of pesticides and animal derived products
- CEA farming appeals to locavores, vegans, and those who prefer organics

# Opportunities to Connect with e3garden

- Get on our mailing list for events and tours
- Become a CSA member
- Buy from our online market
- Listen to our podcasts
- Check out site: e3garden.com
- Try our samples!

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# Questions

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## Contact Info:
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## Discussion

# Appendix