

Kratky Hydroponic Gardening

Effects of Natural vs. LED Plant Light,
Container Type & Seed Propagation/
Plant Support Media on Plant Growth

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Project Description

Goal:

- Explore the use of the Kratky Hydroponic Method as a means of growing indoor, winter lettuce(s) & herbs
- Explore the impact of light, container type & seed propagation/plant support media on plant growth

What is the Kratky Hydroponic Gardening Method?

- The **Kratky** Hydroponic Gardening Method is a passive hydroponics system which provides a way of **hydroponically** growing plants in a water and nutrient-filled containers without electricity, air stones, pumps, or anything else.
- The system was discovered by B.A. Kratky from The University of the Hawaii CTAHR/TPSS Beaumont Agricultural Research Center in 1993.
- The Kratky research paper entitled “*Three non-circulating hydroponic methods for growing lettuce*” was published in 2009.

How Does the Kratky Hydroponic Gardening Method Work?

In its simplified form...

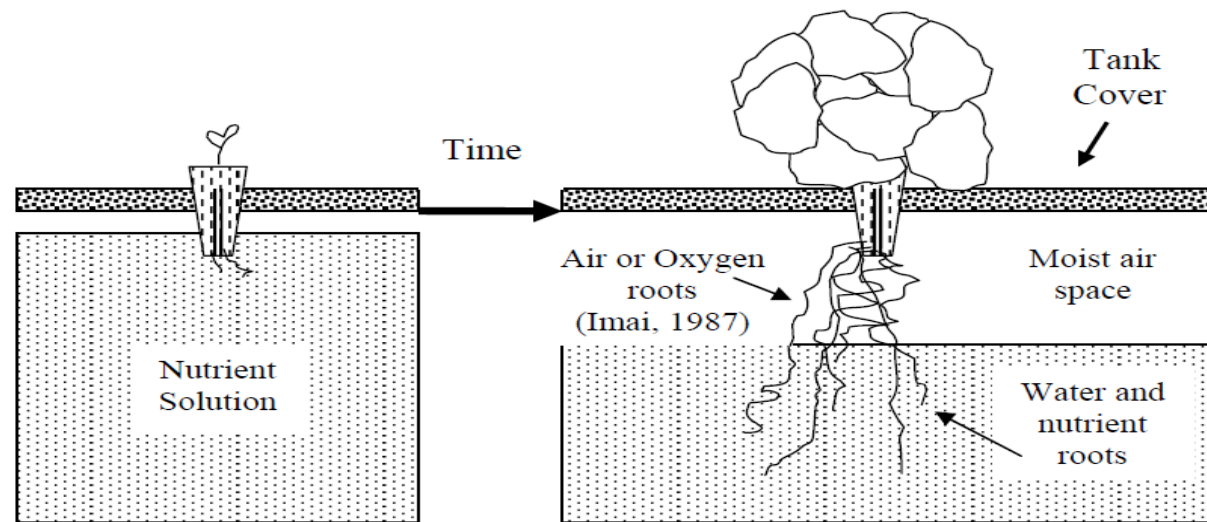
- Germinated plants are placed in a tapered plastic net pot filled with growing medium
- and placed in a darkened, 4 Liter (1.02 gal) plastic bottle filled with nutrient solution.
- The container is filled until the nutrient solution reaches the bottom of the net pot with 1 inch of the bottom of the net pot submerged.
- Over time, plant growth reduces the nutrient solution level, creating an enlarging moist air space. Meanwhile, the root system expands and continues to absorb water and nutrients.
-
- Plants are automatically watered, because the entire growing medium in the net pot becomes moistened by capillary action.

How Does the Simplified Kratky Hydroponic Gardening Method Work?

- Plant growth causes the nutrient solution level to decrease, thus creating an expanding moist air space which is maintained, because the tank cover prevents roots from drying.
- At some point, direct capillary wetting of the substrate is no longer possible, but the expanding root system is capable of absorbing nutrient solution from the tank.
- Roots occupying the moist air space above the solution have been described as oxygen roots whose main function is aeration; these roots experience vigorous lateral and branching growth.
- Roots extending into the nutrient solution are considered to be water and nutrient roots that have limited elongation capabilities, because the oxygen content of the nutrient solution becomes progressively lower with depth. The nutrient solution level may remain the same or be lowered, but it should not be raised because submerging the oxygen roots will cause the plant to 'drown'.

How Does The Kratky Hydroponic Gardening Method Work?

Leaf and semi-head lettuce cultivars are usually harvested at about 6 to 7 weeks after seeding.



Kratky, B.A. 2009. Three non-circulating hydroponic methods for growing lettuce. Proceedings of the International Symposium on Soilless Culture and Hydroponics. Acta Hort. 843:65-72.

What You Can Grow With the Kratky Hydroponic Gardening Method?

- Any plant that grows above ground can be grown
 - Lettuce, spinach, herbs, cucumbers and tomatoes
- Larger plants will need to have the water and mineral solution stay about two inches deep to give the roots access to it while keeping an ample amount of oxygen in the system to support a larger plant
- Monitoring is needed to insure that nutrient solutions are sufficient for plants like tomatoes or peppers

Kratky Design Strategies

- Individual Glass jars - Ball Canning Jars
 - 3 “ Net Pot Baskets fit right into the 32 oz.. & 64 oz.. (1/2 gal) wide mouth jars
- Individual Food safe plastic containers in 16, 32, 64 and 128 oz.. sizes
 - Cut 1 $\frac{3}{4}$ and 2 $\frac{3}{4}$ hole(s) out on the lids for the 2 inch and 3 inch Hydroponic Net Pot baskets
- Hydroponic beds – Large plastic containers with tops that have been cut out to accommodate the Hydroponic Net Pot baskets
- Wood beds lined with plastic and topped with Styrofoam to accommodate Hydroponic Net Pot Bucket Baskets

Project Equipment

Propagator, Tray & Seeds

Heat Mat, Net Pots, Food Safe Jars & Container



Project Equipment

- Hydroponic grow media & support system to promote germination, support plants and inhibit algae growth in the water from sunlight exposure.
 - Examples include Coco Coir, Rock Wool, Oasis Grow Cubes, Rapid Rooter, Rice Hulls, Pumice, Sand Gravel, Wood Fiber, Polystyrene peanuts, Poodle Noodles, Vermiculite, Perlite, Rapid Rooter
 - Coco Coir & Rock wool were tested in this project
 - Coco Coir – Made from ground up dried palm tree husks
 - Rock Wool – Made from rock that has been melted and spun into fibrous cubes and growing slabs
- pH Test Kit
- pH Management Chemicals (control alkalinity vs. acid)
 - pH Up – Contains Potassium Carbonate & Potassium Silicate solution to raise pH
 - pH Down – Contains Phosphoric Acid, Citric Acid & Mono Ammonium Phosphate to lower pH

Project Equipment

Seed Propagation & Plant Support System(s): Coco Coir & Rock Wool

pH Test & Management Chemicals

Coco Coir



Water -Expanded Coco Coir



Rock Wool



Project Equipment

- Hydroponic Nutrients
 - Many from which to choose - Fox Farm Grow Big 3-2-6 (3 Nitro, 2 Phosphorus, 6 Potassium) was used in this project
- Hydroponic Clay Pebbles – plant support
- Wrap to block sunlight and prevent algae
 - Brown paper, tin foil, black plastic bags etc.
- LED Grow lights

Project Equipment

Hydroponic Nutrients & Wrap

Clay Pebbles & LED Lights



Project Equipment Costs

(Multipurpose - Can be used to germinate soil based plant seeds and other purposes)*

- 1- LifeLite LED 45 Watt Grow Lite 4-Strip-Kit – \$42.99 – Lower Shelf* *(Indoor Plant Growing)*
- 1-Namo Tek Seed Germination Heat Mat – \$10.99 * *(Germination)*
- 1- Early Grow 24x15 Domed Seed Propagator - \$39.99 * *(Germination)*
- 1 Bag - Coco Coir Pebbles (Qty 100) - \$18.75 * *(Germination & Plant Support)*
- 1 Bag – Rock Wool (Qty 200) - \$16.95
- 1 Bag - Hydroton Expanded Clay Pebbles (10 Liter Bag) – 17.43
- 1 - Jovitec Net Pot Set (3 in & 2 in – 25 each) - \$15.99
- 50 – 32 oz. Plastic Soup Containers - \$20.98
- 10 – 1 Gal Food Safe Containers - \$25.95

Project Equipment Costs

(Multipurpose - Can be used to germinate soil based plant seeds and other purposes)*

- 12 – 32 oz. Ball Glass Jars – \$19.94* *(Canning)*
- 12 – 16 oz. Ball Glass Jars - \$11.86* *(Canning)*
- 1 Bag - Plastic black-out bags (Qty 200) - \$13.39 *(Lunch & Goodie Bags)*
- 1 Gal Fox Farm Hydroponic Nutrient – 36.37
- 1 - General Hydroponics pH Test & Control Kit - \$14.31
- Lettuce & Herb Seeds (3,000 Seeds) - \$19.22 * *(Seed Germination for Gardening)*
- ***Total Project \$325.11 (*Cost after multipurpose considerations \$147.98)***

Project Description

Method

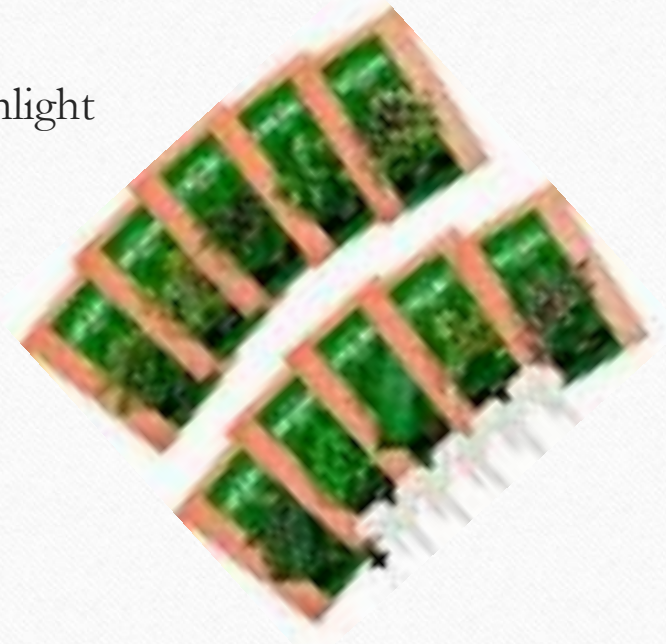
Method: Four groups of plants were studied to learn about Kratky Hydroponic gardening and to determine the potential impact of natural vs. artificial light and container selection on plant growth:

- Group I – Lettuce(s):
 - Growing in 1 Gal (128 oz.) plastic & 32 oz.. glass containers in natural sunlight (South-West (SW) Exposure)
 - 1 Gal plastic containers were filled with 88 oz. nutrient solution
 - 32 oz. glass containers were filled with 24 oz. nutrient solution
- Group II – Lettuce(s):
 - Growing in same container types under 45 Watt LED grow lights & filled with same amount of nutrient solution

Project Description

Method

- Group III – Herbs:
 - Growing in 16 oz.. glass & 32 oz.. plastic containers in natural sunlight (South-West (SW) Exposure)
 - 32 oz. plastic containers were filled with 24 oz. nutrient solution
 - 16 oz. Glass containers were filled with 12 oz. nutrient solution
- Group IV – Herbs:
 - Growing in same container types under 45 Watt LED grow lights & filled with same amount of nutrient solution



Project Description - Plants

N=26

LETTUCE PLANTS - 12 Plants

- 4- Green Ruffic Endive
- 4- Oak Leaf Lettuce
- 4- Black Seeded Simpson Lettuce



HERB PLANTS - 14 Plants

- 2 each - Parsley, Dill, Chives, Mint – germinated from seed – Total 8
- 2 each - Basil, Rosemary and Sage – from Cuttings – Total 6



Systematic Instructions

Germination

1. Acquire required equipment
2. Prepare trays and propagator to germinate seeds
3. Place seeds in water-saturated Coco Coil or other growing media
(Rock Wool Recommended – cleaner and easier to work with)
4. Place water-saturated Coco Coil seeds (or Rock Wool) into heated propagator and add water to the bottom of each tray
5. Keep trays moist with a small amount of water during germination
6. Watch them grow - Plants are ready for transplant when the roots are visible at the bottom of the growing media

Systematic Instructions

Container & Hydroponic Solution Preparation

1. Prepare the Hydroponic containers (4 Liter container specified by Kratky – other sizes will work)
 - a) Cut out holes in lid tops. Clean the Ball Glass Jars
2. Prepare the Hydroponic Solution:
 - a) Fill a 1 Gal container with water
 - b) Add 2 Tsp. Hydroponic Nutrient/Gal
 - c) Using a pH Test Kit or pH Monitor, test the water pH level
 - d) Adjust the pH by adding pH Up or pH Down solution to establish a pH of 5.8-6.5 for growing hydroponics
3. Fill the containers
 - a) Place an empty net pot in each container and fill each container until the nutrient solution fills the bottom of the net pot by 1 inch

Systematic Instructions

Transplanting Plants into Containers

1. Add a small amount of clay pebbles to the bottom of each net pot in each container
2. Transplant one coco coil or rock wool plant into the bottom of each net pot and surround the plant with clay pebbles on sides & top
3. Wrap each container to block out light and prevent algae growth
4. Place the containers and jars in a sunny location or under LED grow lights
5. Watch them grow
6. Periodically remove the wrap and observe nutrient level and root growth
7. Adjust nutrient levels as necessary in the beginning and as roots are growing

Harvesting

When the water in the container is nearly gone, it is time to harvest the plant

- Cut the lettuce tops from the outside in, leaving the rest of the plant intact
- Herbs cuttings can be taken at any time during the growing cycle when ripe
- Plants will continue to regenerate and grow with each cutting
 - Texture and taste changes will occur with each cutting
- If you want to keep the plant growing longer, lift the lid and add more nutrient solution

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

- December 10, 2018 – A equipment acquired and prepared
- December 12, 2-18 – Seed germination initiated
- January 1-Jan 2, 2019 – Germinated seeds transplanted
- Jan 2- February 3, 2019 – Plant growth was monitored daily & photographed weekly on Sundays
 - Lost 1 Dill and 1 Oak Leaf Lettuce plant immediately following transplant
 - Mint, and chive herbs never grew
- Jan 13 – Weekly Progress Monitoring:
 - Roots visible on all plants in Coco Coil, but some roots were not growing down into the nutrient solution, water levels needed to be adjusted to keep them moist

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

- Jan 16 – Rock Wool Lettuce Seed Germination initiated
- Jan 20 – Weekly Progress Monitoring:
 - Slight water drop since Jan 12
 - Water added to plants without roots to keep them moist
 - Water is clear in all plants – no algae
 - Roots are white and healthy
 - Herb plants from seed continue to grow in coco coil with limited visible top growth and no visible root growth in nutrient solution
 - Herb cuttings have significant root growth but limited top growth
 - LED Lettuce plants continue to surpass Natural light plants in both top and root growth

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

- Jan 27 – Weekly Progress Monitoring:
 - LED plants are outperforming Natural Light Plants
 - Lettuce plants growing in 1 Gal containers are larger than those growing in 32 oz.. Ball Jars
 - LED Lettuce Plants are 3 times the size of Natural Light Plants
 - LED Plant root growth is flourishing and in some plants massive, while Natural Light root growth is minimal or not at all
 - Lettuce roots are white, healthy and massive, filling most of the container
 - Water is clear in all plants – no algae

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

Feb 3 – Last Progress Monitoring –Project End & Harvest:

Black Simpson Lettuce:

- LED Plant Top Growth - Height – 15 Inches Tall
- LED Plant Root Growth - Length – 12 Inches Long
- Natural Light Plant Top Growth - Height – 10 inches Tall
- Natural Light Plant Root Growth - Length - 3 Inches Long

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

Feb 3 – Last Progress Monitoring –Project End & Harvest:

Rufic Endive:

- LED Plant Top Growth - Height – 14 Inches Tall
- LED Plant Root Growth - Length – 12.5 Inches Long
- Natural Light Plant Top Growth - Height – 9 inches Tall
- Natural Light Plant Root Growth - Length - 0 Inches Long

Measurements from Oak Leaf LED & Natural Light Plants were insignificant and were therefore not recorded

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

Feb 3 – Last Progress Monitoring – Project End & Harvest:

Nutrient Levels - 1 Gal Plastic Containers:

- Black Simpson Lettuce:
 - LED – Dropped from 88 oz. to 37 oz. (minus 51 oz.)
 - Natural Light – Dropped from 88 oz. to 80 0z (minus 8 oz.)
- Rufic Endive:
 - LED – Dropped from 88 oz. to 11 (minus 77 oz.)
 - Natural Light – Dropped from 88 oz. to 70 oz. (minus 18 oz.)

Project Timeline

December 10, 2018 to February 3, 2019 – 56 DAYS

Feb 3 – Last Progress Monitoring – Project End & Harvest:

Nutrient Levels - 32 oz. Containers:

- Black Simpson:
 - LED – Dropped from 24 oz. to 22 oz. (minus 2 oz.)
 - Natural Light – Remained the same
- Rufic Endive
 - LED - Dropped from 24 oz. to 16 oz. (minus 8 oz.)
 - Natural Light – Dropped from 24 oz. to 20 oz. (minus 4 oz.)

Project Description

Temperature & Daylight

- During this period:
 - The average daily high temperature was 41.7 Degrees
 - The average daily low temperature was 26.1 Degrees
 - The average number of daylight hours was 9 hours, 31 minutes and 43 seconds

Project Description

Weather Conditions

- There were 25 sunny days
- There were 16 mostly cloudy days
- The 10 cloudy days
- There were 10 rainy days
- There were 0 snow days
- Total 56 Days

Project Findings

- Start up costs were expensive
- Grow lights combined with timers were expensive, but essential, easily installed, set and managed
- Initial pH testing and adjustment required practice – several trials were needed before target levels were achieved
- Lack of sunlight drastically impacted natural light plant growth due to the inability of the plants to perform photosynthesis

Project Findings - Containers

- All container types worked and yielded results
- The 1 Gal plastic containers worked best, producing the best lettuce yield
- The 32 oz.. glass & plastic containers yielded lettuce but the lettuce was smaller than the 1 Gal containers
- Although the 16 oz.. glass jars worked for herb cuttings, top growth was minimal even though root growth was substantial in both LED & Natural Light Groups
- Ball glass jars were easier to prepare & use than plastic
 - No top cutting required
 - The 3 inch net pots fit perfectly into the 32 oz. Glass Ball Jars
 - Nutrient level monitoring was easier than plastic – glass jars were clear

Project Findings – Planting Media

Coco Coir

- Roots grew into the Coco Coir instead of down into the nutrient solution on germinated seeds
- Lost 2 plants (1 Oak Leaf Lettuce, 1 Dill)
- Mint plants never grew from seed
- Coco Coir filling fell into the nutrient solution making it a bit dirty

Rock Wool:

- Cleaner - no filling fell in the nutrient solution
- Better germination
- Easier to transplant plants after germination

Project Findings – Clay Pebbles

Clay Pebbles Were Messy:

- Fell off of the tops of the plastic containers onto the floors
- Fell into the nutrient solution and changed the color of the nutrient solution
- After 1 week, the clay pebbles on the 32 oz.. plastic container tops were replaced with black wrap to facilitate monitoring

Plant Growth Findings - Lettuce

- Plants grown under LED Grow lights yielded better results than plants grown in natural light
 - Natural light lettuce(s) did not grow well due to lack of light and the inability to perform photosynthesis adequately
 - When LED lights were added to the natural Light Plants during the last 5 days of the project, root & top growth improved
 - Oak Leaf Lettuce proved to be difficult to grow in both natural and LED light regardless of container type – minimal growth
 - This may have had something to do with germination and/or the quality of the seed

Plant Growth Findings - Lettuce

- Plants in 1 gal containers (Kratky recommended) & under LED light grew best
 - Top growth was better:
 - Plants were fuller & taller`
 - Plants grew faster
 - Root growth was superior
 - Roots were at least 3 times the size (longer and wider) than the natural light plants
- Lettuce grown in 32 oz. plastic & glass containers was smaller than those grown in the 1 Gal containers
 - Probably due to lower Oxygen levels from limited plant nutrient absorption (See Feb 3)

Plant Growth Findings - Herbs

- Root & top growth on herb cuttings was superior to germinated seed plants
 - Top growth was similar in both the natural and LED herb plants but Root Growth was significantly greater in LED plants
- Additional nutrient solution had to be added to the Coco Coil herb plants germinated from seed to keep them moist until the roots began to grow downward into the solution
 - Probably should have delayed transplanting until roots were more firmly established during the germination process

Plant Growth Findings

- Rosemary, Sage & Basil herb cuttings grew in 32 oz.. plastic and 16 oz.. glass containers in both natural and LED light although top growth was small
- Mint, Chives & Dill grown from seed failed to grow in any container type in Natural or LED light (Probably due to germination and seed quality issues)
- Plants were healthy with no signs of disease or pests
- Root and top growth of natural light plants increased within 5 days of exposure to LED lights and continued to improve

Conclusions

- The project, as designed supported the theory & findings of the Kratky Hydroponic Method Research Paper
- With the exception of the Oak Leaf Lettuce, the LED Lettuce grew very well and yielded crops which are about the same size as those grown in soil
- Although the yield was smaller in size, 2 out of 3 lettuce species grew in the 32 oz.. plastic & glass containers even though the containers did not meet the Kratky 4 Liter specifications
- Herb plant growth occurred in all containers regardless of size & type (except for Mint, Dill & Chives which were germinated from seed)
- Herbs – Root growth was significant in cuttings, but top growth was not robust. This is probably due to minimal nutrient levels which were absorbed by the plant.

Conclusions

- Lettuce grew best in 1 Gal plastic containers which held 1 gal of solution vs. 1.04 gal in 4 Liter Kratky recommended container (container size & nutrient solution reduction did not affect growth)
- Hydroponics appears to be a very clean and healthy method for plants. There were no signs of any disease or pests throughout the project
- Growing hydroponics requires a significant amount of space and management to insure success
- Plants will not flourish without LED lighting – A separate plant growing area is needed unless you don't mind having LED lights in your everyday living environment
- Next steps – Spring & Summer:
 - Grow lettuce in spring & summer:
 - Use Rock wool, 1 Gal plastic and ½ Gal glass containers
 - Determine if spring & summer natural light conditions improve plant growth when compared to LED light

Progress Monitoring Photos
December 12, 2018 - Feb 3, 2019

Project Photos

Seeds & Cuttings



Seedlings Soaking in Cocoa Coir Pellets in the Heated Propagator – Day 1 (Dec 12)



Germination - Day 3 (Dec 15)

Internal Propagator Temperature 92 Degrees



Transplant Day - Day 23 (Jan 1)

The Candidates – Germinated Coco Coir Seeds



Transplant Day - Day 23 (Jan1)

The Candidates - Cuttings



Transplant Day - Day 23 (Jan 1)

Two Container Types & Three Sizes— Glass & Plastic



Transplant Day - Day 23 (Jan1)

Plants in the Sun



Grow Stations Up – Day 24 (Jan 2, 2019)

All Plants in Place

Natural (Upper Level & LED (Lower Level)



Natural Light Lettuce Growth Progress – Top Growth

Jan 13 - (12 Days After Transplant)



LED Light Lettuce Growth Progress – Top Growth

Jan 13 (12 Days After Transplant)



Lettuce Progress – Root Growth
Jan 13 - (No Extended Roots on LED Oak Leaf Lettuce
or on Natural Light Plants)

Black Simpson Lettuce



Rosemary Cutting



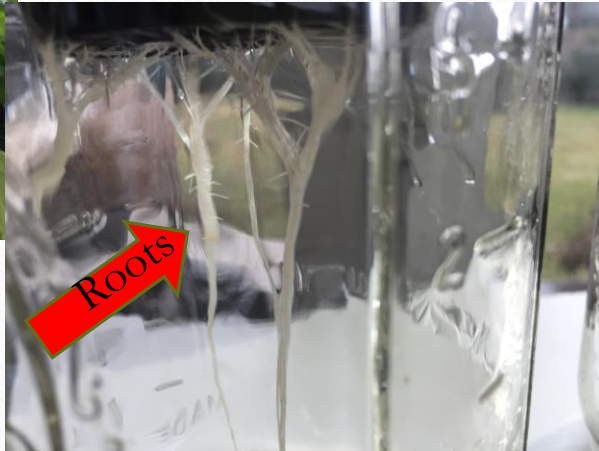
Green Rufic Endive





Plant Progress – LED Lettuce(s) Top & Root Growth Jan 13

Black Seeded Simpson Lettuce



Green Rific Endive Lettuce

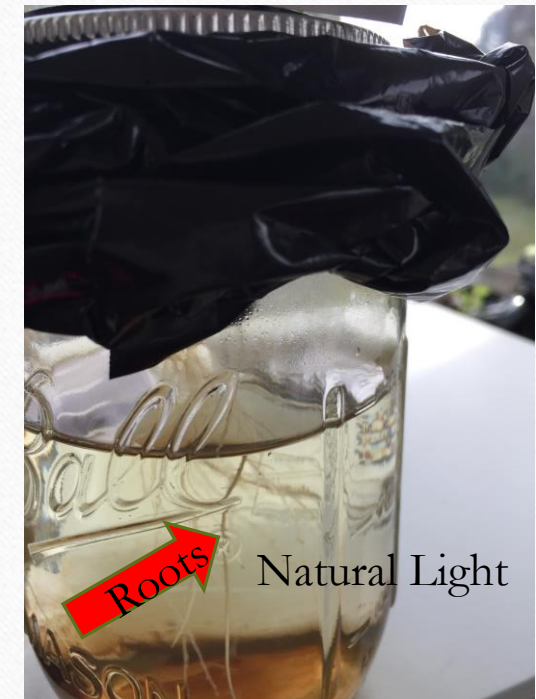


Plant Progress – LED & Natural Light Herbs – Top & Root Growth

Jan 13

Rosemary Root Growth

Sage Root Growth



Rock Wool pH Nutrient Seed Propagation Jan 16

1 Dill

2 Mint

1 Chive

6 Black Simpson Lettuce

6 Oak Leaf Lettuce

4 Rific Endive Lettuce

Purpose:

Test Rock Wool as a support system on lettuce
Test Impact of Using pH Nutrient Solution in
Seed Germination

Replace Failing Coco Coil Plants

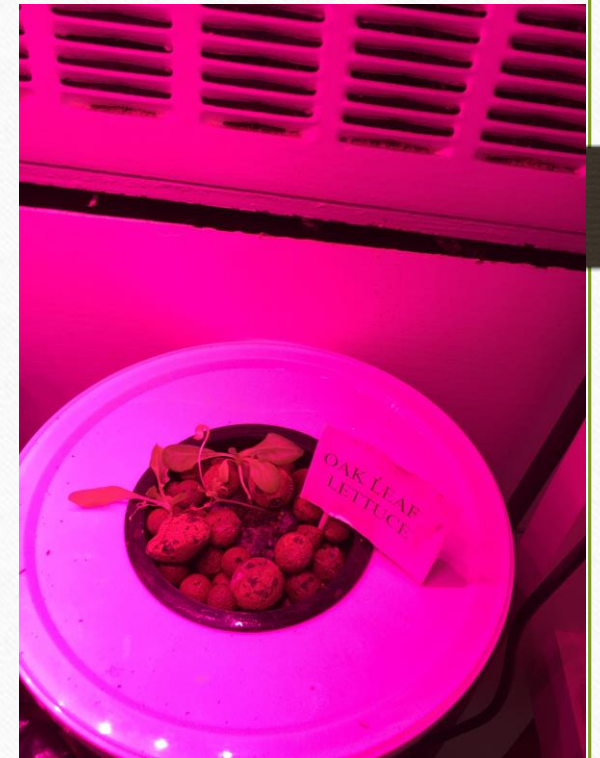




Jan 20 – Day 42 – 20 Days After Transplant
Plant Progress -Top Growth
Natural Light Plants



Jan 20 – Day 42 – 20 Days After Transplant
Lettuce Progress – Top Growth
LED Lettuce Plants



LED Herb Top Growth
Progress
Rock Wool Seed
Propagation Progress

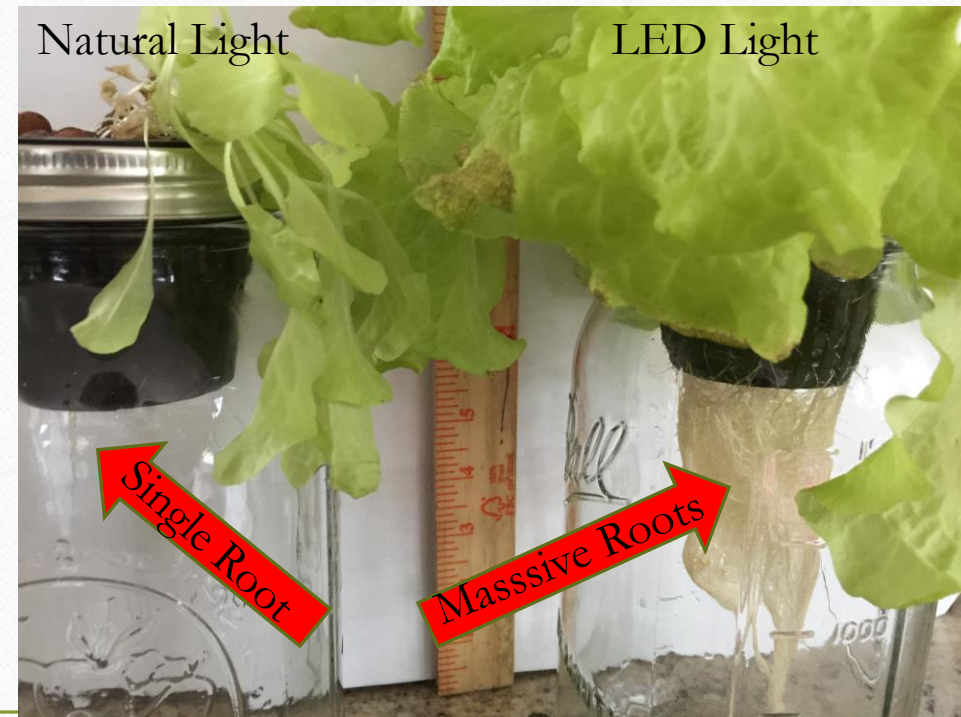


Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 1 Gal Plastic Containers
Comparison of Natural vs LED Lettuce Top & Root Growth

Black Simpson Lettuce - Top Growth



Root Growth



Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 1 Gal Plastic Containers
Comparison of Natural vs LED Lettuce Top & Root Growth

Rufic Endive Lettuce – Top Growth



Root Growth



Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 1 Gal Plastic Containers
Comparison of Natural vs LED Lettuce Top & Root Growth

Oak Leaf Lettuce – Top Growth

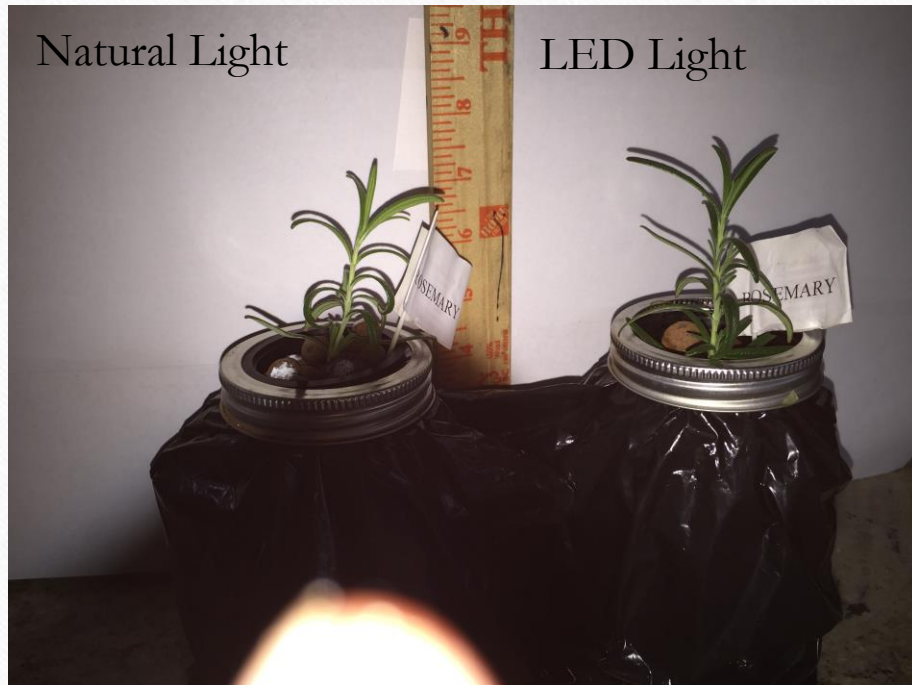


Root Growth

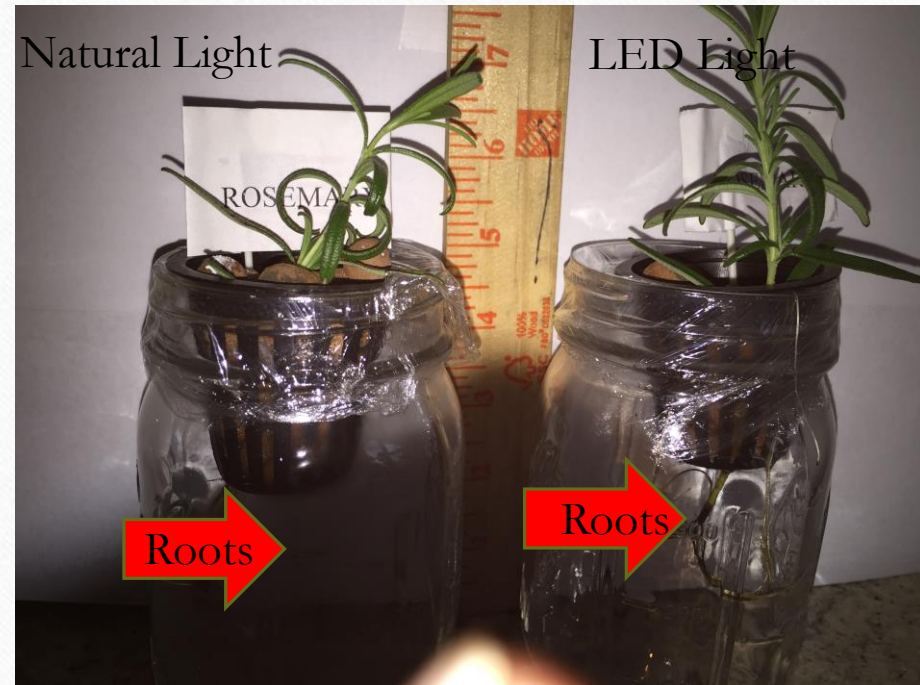


Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 16 oz.. Glass Containers
Comparison of Natural vs LED Herbs- Top & Root Growth

Rosemary – Top Growth



Root Growth

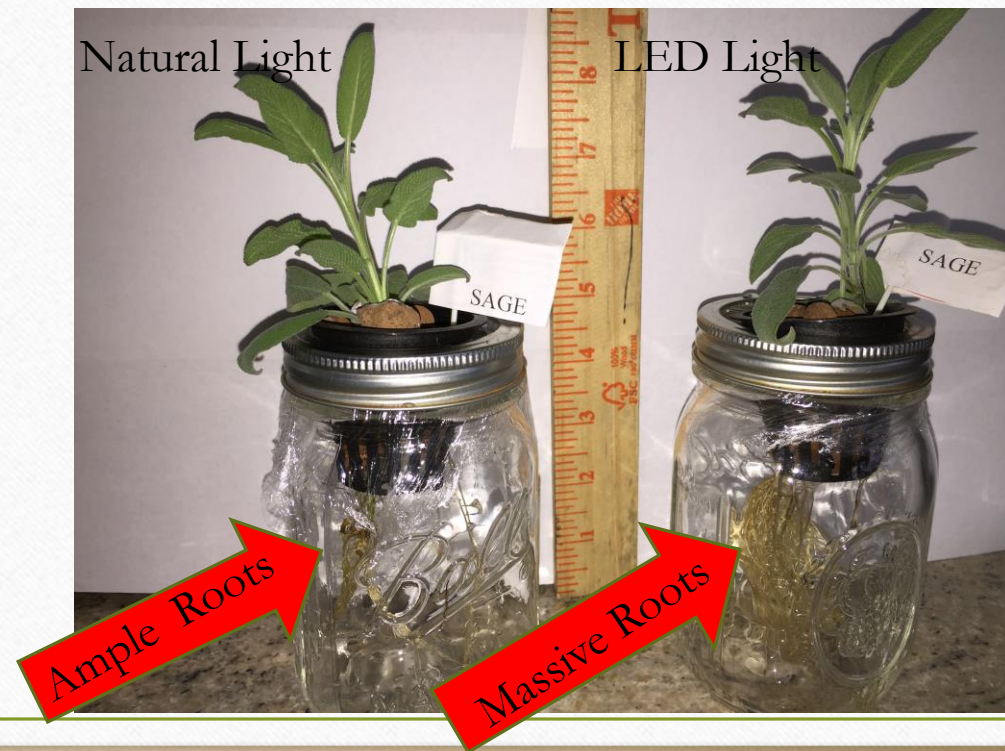


Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 16 oz.. Glass Containers
Comparison of Natural vs LED Lettuce Top & Root Growth

Sage – Top Growth



Root Growth

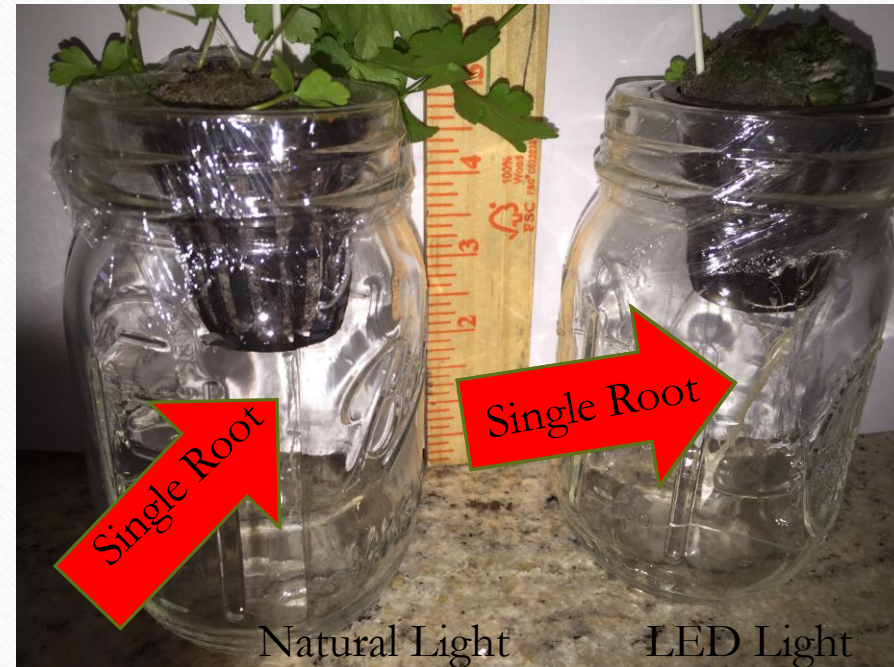


Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 32 oz.. Plastic Containers
Comparison of Natural vs LED Herbs - Top & Root Growth

Parsley – Top Growth



Root Growth



Jan 27 – Day 49 – 27 Days After Transplant
Plant Progress – 32 oz.. Plastic & 16 oz.. Glass Containers
Comparison of Natural vs LED Herbs - Top & Root Growth

Basil - Top Growth



Root Growth



Progress Monitoring

February 3, 2019

Day 56

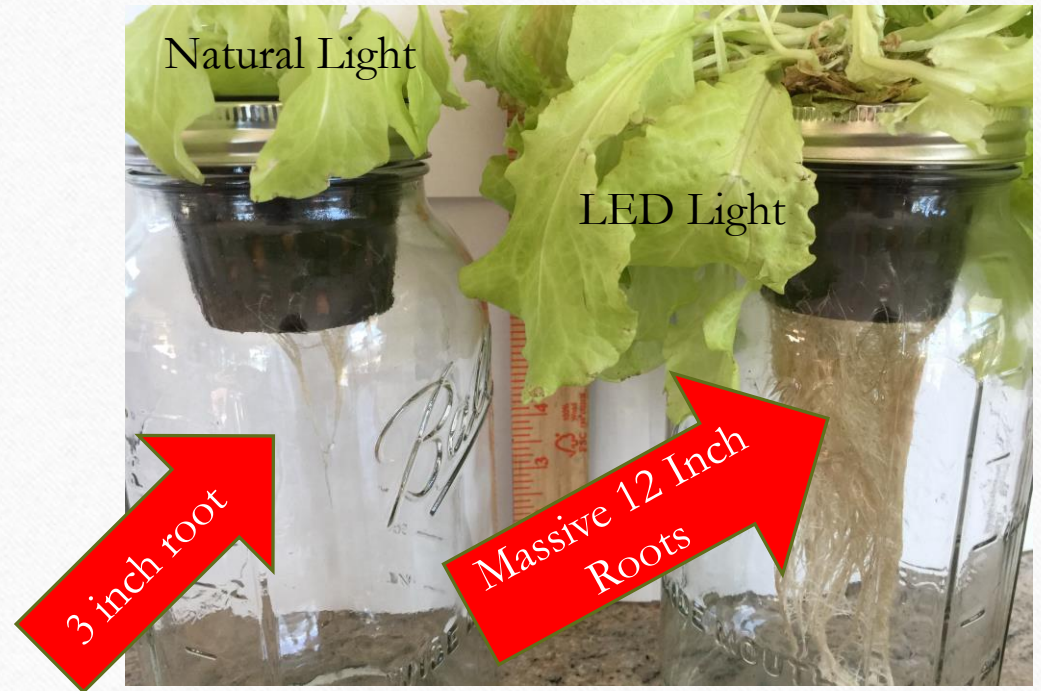
Last Day of Project

February 3 – Day 56 - 34 Days After Transplant
Plant Progress – 1 Gal Containers
Comparison of Natural vs LED Lettuce - Top & Root Growth

Black Simpson Lettuce - Top Growth



Root Growth



Feb 3 – Day 56 – 34 Days After Transplant
Plant Progress – 1 Gal Container
Comparison of Natural vs LED - Top & Root Growth

Rufic Endive - Top Growth

Root Growth

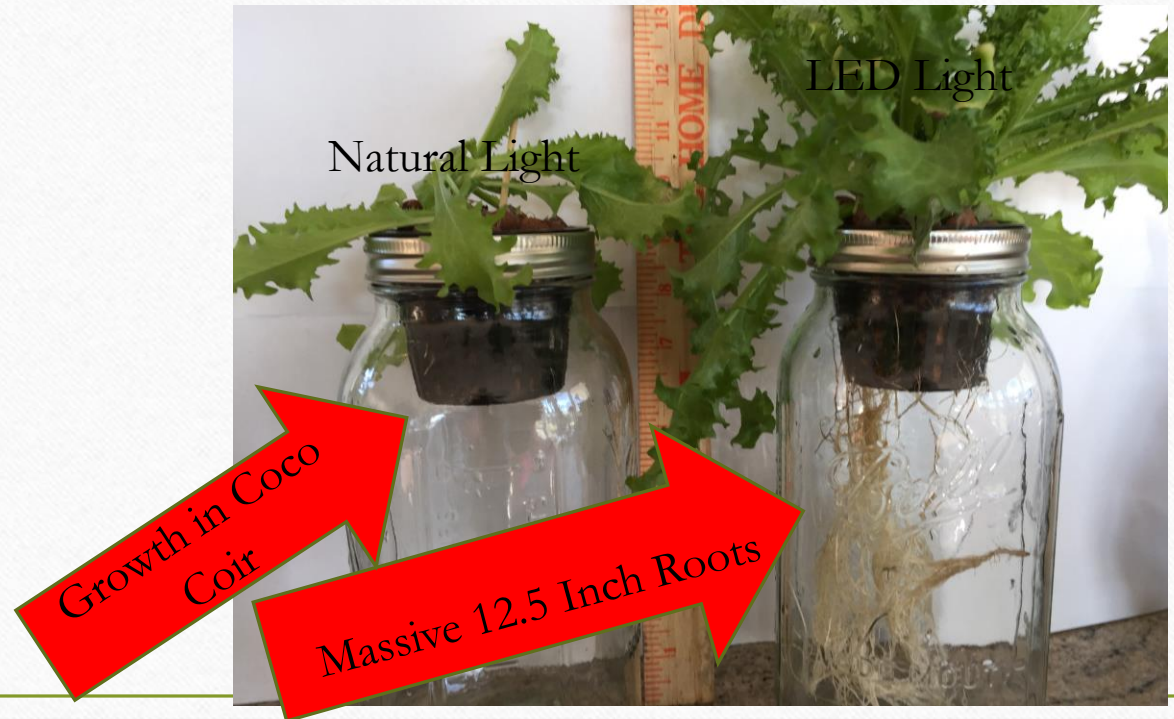


Feb 23 – Day 56 – 34 Days After Transplant
Plant Progress – 32 oz.. Container
Comparison of Natural vs LED Lettuce - Top & Root Growth

Top Growth



Root Growth



Hydroponic Growing Resources

Hydroponic Growing Resources

- Kratky Hydroponics- The Original Scientific Paper: “Kratky, B.A. 2009. Three non-circulating hydroponic methods for growing lettuce. Proceedings of the International Symposium on Soilless Culture and Hydroponics. Acta. Hort. 843:65-72. University of Hawaii CTAHR/TPSS Beaumont Agricultural Research Center 875 Komohana St. Hilo, Hawaii 96720 USA - <http://www.ctahr.hawaii.edu/hawaii/do...>
- Video –”Hydroponic Lettuce” – University of Florida, Hannah Wooten <https://www.youtube.com/watch?v=GQey35Tt24I>
- Article – “How to Grow Hydroponic Lettuce” - Wikihow.com: <https://www.wikihow.com/Grow-Hydroponic-Lettuce>
- Video-”Off-the-grid Hydroponics – Kratky Method” - <https://www.youtube.com/watch?v=E49GgFGvqm4>
- Video- “Easy to Grow Hydroponic Lettuce Using the Krastky Method”- U-Tube, Tikki O - <https://www.youtube.com/watch?v=2ezeP1VAEoc>

Hydroponic Design & Build Resources

- Article “16 Easy Hydroponic DIY Plans...” -
https://www.youtube.com/watch?v=2eze_1VAEoch
<https://www.greenandvibrant.com/hydroponic-plans>
- Article – How to Build a Home-Made Hydroponics System
<https://www.wikihow.com/Build-a-Homemade-Hydroponics-System>
- Article – How to build a Hydroponic Garden
<https://www.wikihow.com/Build-a-Hydroponic-Garden>
- Video-”Kratky Method Equipment” -
<https://www.youtube.com/watch?v=ARoqvtq3Qfs>

Hydroponic Grow Media & Transplant Resources

- Video “Growing Medium – Which Should You Choose & Why”
<https://www.youtube.com/watch?v=ZRrcA-7fgmA>
- Video – “How To Transplant Coco Coir Into Hydroponic Kratky System - Step By Step” - https://www.youtube.com/watch?v=r5ChpLcR_7E
- Article – “How to maintain Hydroponic Reservoir”:
<https://www.wikihow.com/Maintain-a-Hydroponic-Nutrient-Reservoir>

Hydroponic Classroom Resources

- National Agriculture in the Classroom – Curriculum, Lesson Plans & Handouts:
https://www.agclassroom.org/teacher/matrix/search_result.cfm
- Hershey, David R. “Solution Culture Hydroponics: History and Inexpensive Equipment.”
The American Biology Teacher, Volume 56, No. 2, Feb 94 (111-118) -
<https://www.agclassroom.org/me/matrix/lessonplan.cfm?lpid=300>
- Greentree Hydroponics- “Hydroponics & Indoor Growing Learning Center” -
<https://www.hydroponics.net/learn/>
- Test Tube Hydroponics Kit – <https://agclassroomstore.com/test-tube-hydroponics/>

Thanks for Looking!

Bon Appetite!

