Module 2
Hydroponic Substrate and Plant Propagation

2026 Greenhouse Hydroponic Tomato Workshop with Dr. Triston Hooks

Outline

1. Substrate Overview
2. Alternative Substrates
3. Seed Propagation
4. Boosting and Transplanting

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Grodan

Hydroponic Substrate

Review

- Hydroponics is soilless which means it doesn't rely on soil in the ground for plant production

- However, hydroponics commonly uses a substrate to hold moisture and anchor the plant

Grodan

Hydroponic Substrate

Substrate Overview

- In general, hydroponic substrate is minimal and inert, since the nutrient solution provides water and all essential elements

- Inert means chemically inactive (no fertilizer, organic material, or micro-organisms)

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Hydroponic Substrate

Substrate Overview

- However, substrate can play a vital role in the early stages of plant production such as:
  - Germination
  - Seedling root growth
  - Transplanting

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Jiffy

Hydroponic Substrate

Substrate Overview

- Substrate can also be critical for the hydroponic production of large vine crops because the growing time is longer and the roots need sufficient space/volume
    - Tomato
    - Pepper
    - Cucumber

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Hydroponic Substrate

Substrate Overview

- Therefore, choosing the right substrate is important for successful hydroponic plant production
- Moreover, knowing the characteristics of each substrate will make you a skilled hydroponic grower

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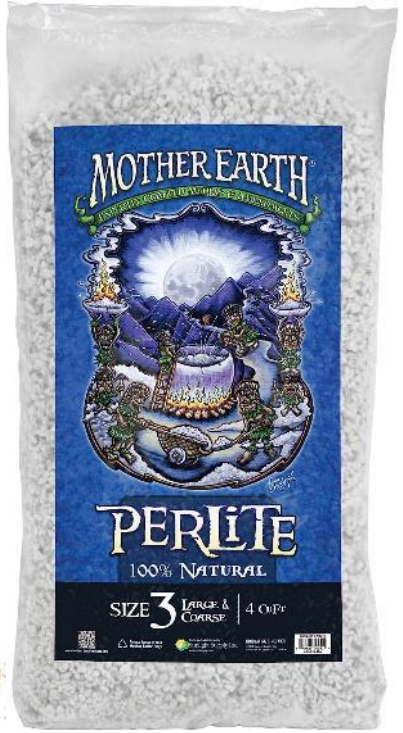

Hydroponic Substrate

Substrate Overview

- There are many different types of hydroponic substrates to choose from!
  - *Which substrate should I choose?!*
  - *Which substrate is the best?!*

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- Plugs

- Sheets/cells

- Blocks

- Slabs

Hydroponic Substrate

Substrate Overview

- Hydroponic substrates come in different forms, shapes, and sizes for various applications of hydroponic plant production
    - Leafy greens
    - Vine crops
    - Cannabis
    - Organic, etc.

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Hydroponic Substrate

Common Substrates

- Rock wool is the industry standard hydroponic substrate, worldwide
- Rock wool is made from superheating basalt rock and spinning it into fibers
- Rock wool is clean, uniform, and easy to work with

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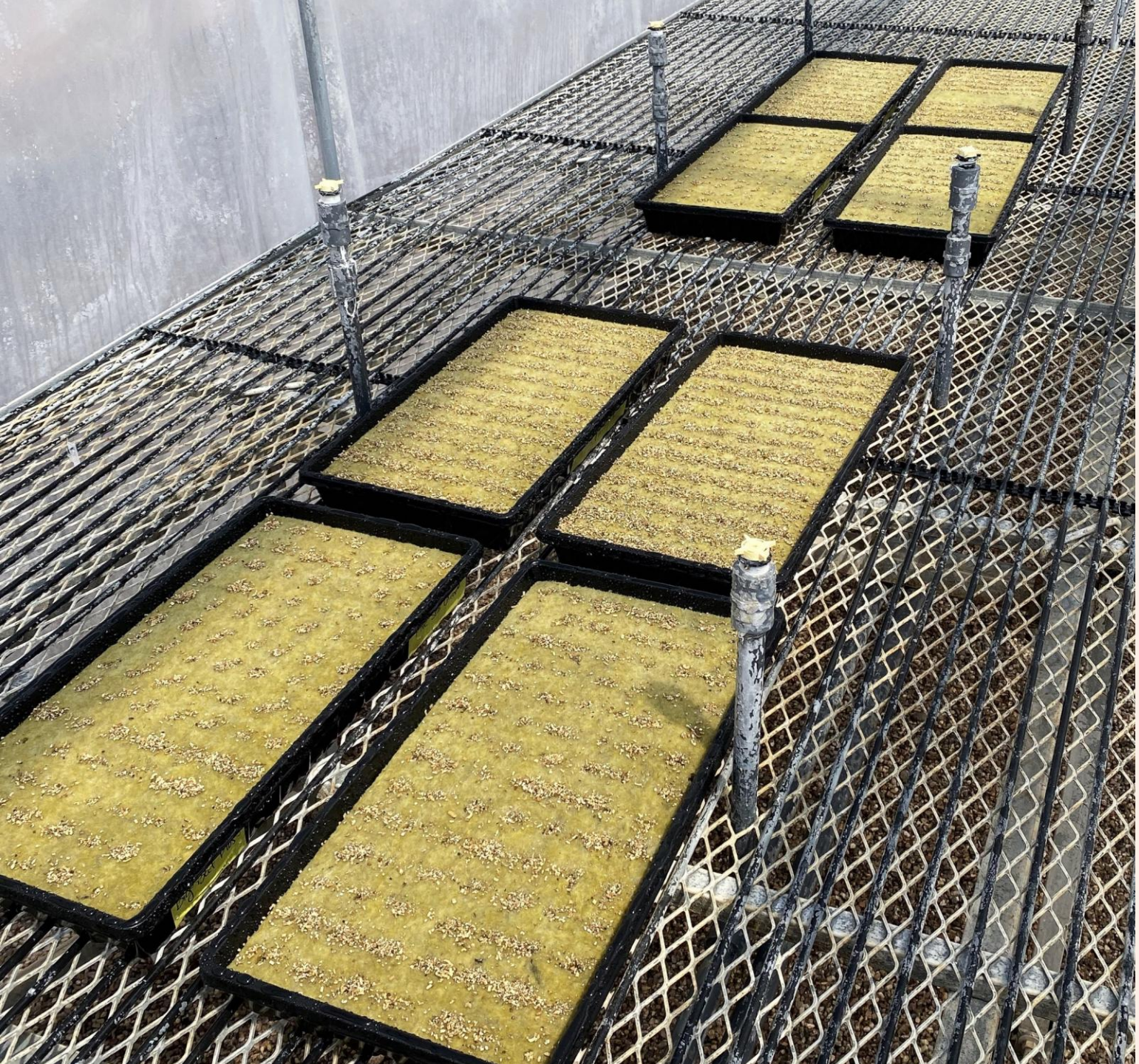

Hydroponic Substrate

Common Substrates

- Rock wool is also versatile and comes in many different forms, shapes, and sizes for various applications of hydroponic plant production
- Rock wool sheets are commonly used for seed germination

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Hydroponic Substrate

Common Substrates

- Rock wool sheets fit in industry standard 1020 trays
- The sheets are divided into cells with common sizes of:
  - 1 in. (25 mm) for leafy greens (200 cells/sheet)
  - 1.5 in (36 mm) for vine crops (98 cells/sheet)

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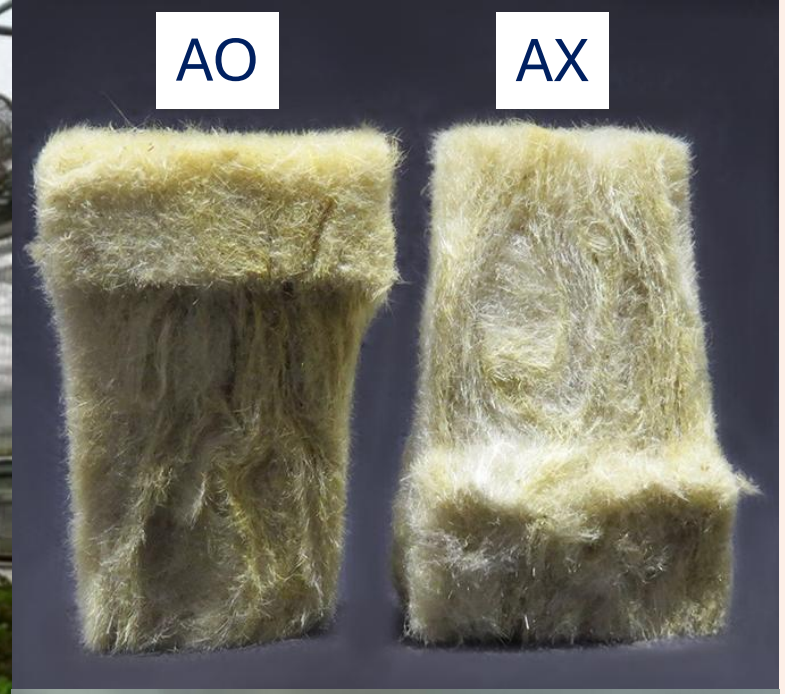
Beaver Plastics and Hort Americas



Hydroponic Substrate

Common Substrates

- Rock wool 25 mm cells are commonly used for leafy greens in DWC and NFT systems
- The well to hold the seed is placed at the wide or tapered end depending on the system
  - AO = DWC floating boards
  - AX = NFT channels

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Hydroponic Substrate

Common Substrates

- Rock wool blocks are larger and used for transplanting vine crops and cannabis
- Common sizes are 8 or 10 cm blocks with 4 cm holes to fit 36 mm rockwool cells

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Hydroponic Substrate

Common Substrates

- Rock wool slabs are large, rectangular, and designed to lay down flat on gutters in a drip hydroponic system for vine crop production

- Common slab size is 100 x 20 x 7.5 cm and can support up to six blocks (plants)

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Hydroponic Substrate

Common Substrates

- Rock wool is versatile and easy to use for many different crops and hydroponic systems
- However, rock wool is generally a one-time use product that is difficult to reuse, recycle, or compost*

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Hydroponic Substrate

Common Substrates

- Coco coir is made from the husks of coconuts
- Coco coir is a popular alternative substrate because it is made of organic material that can be composted
- Coco coir plugs, blocks, and slabs are dehydrated and must be rehydrated before use

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Hydroponic Substrate

Common Substrates

- Rehydration requires thorough soaking from above and below (over-head and sub-irrigation) to ensure uniform moisture for optimal seed germination and seedling root growth

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Hydroponic Substrate

Common Substrates

- Performance wise, coco coir substrate can be comparable to rock wool
- However, coco coir can be more challenging due to its organic nature, making it less uniform
- Coco coir can also be messy to handle during rehydration germination, and transplanting

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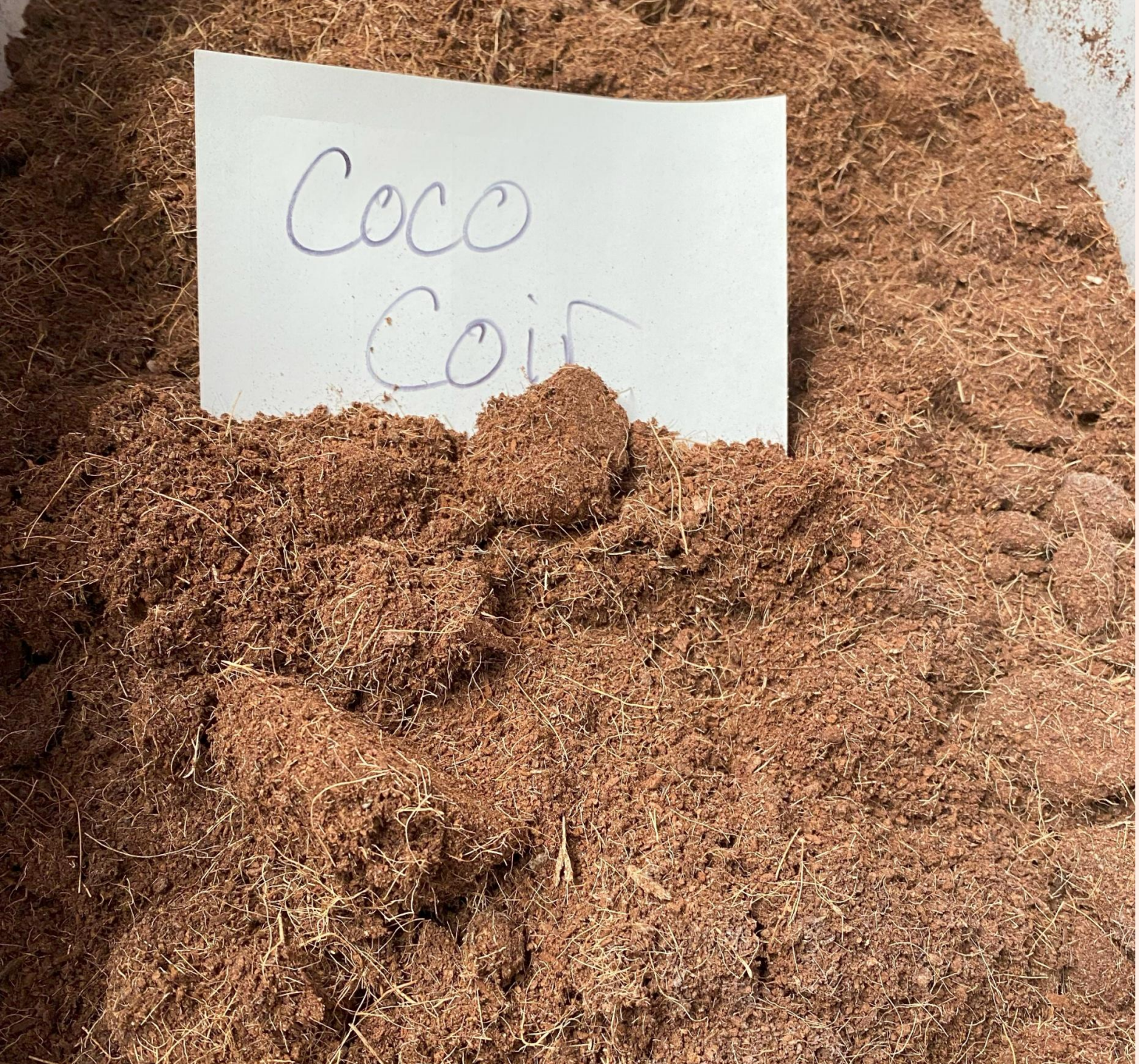

Hydroponic Substrate

Common Substrates

- Coco coir can also be used as a loose substrate individually or in a custom mix
- *Example mix: 50% coco, 25% perlite, 25% vermiculite*

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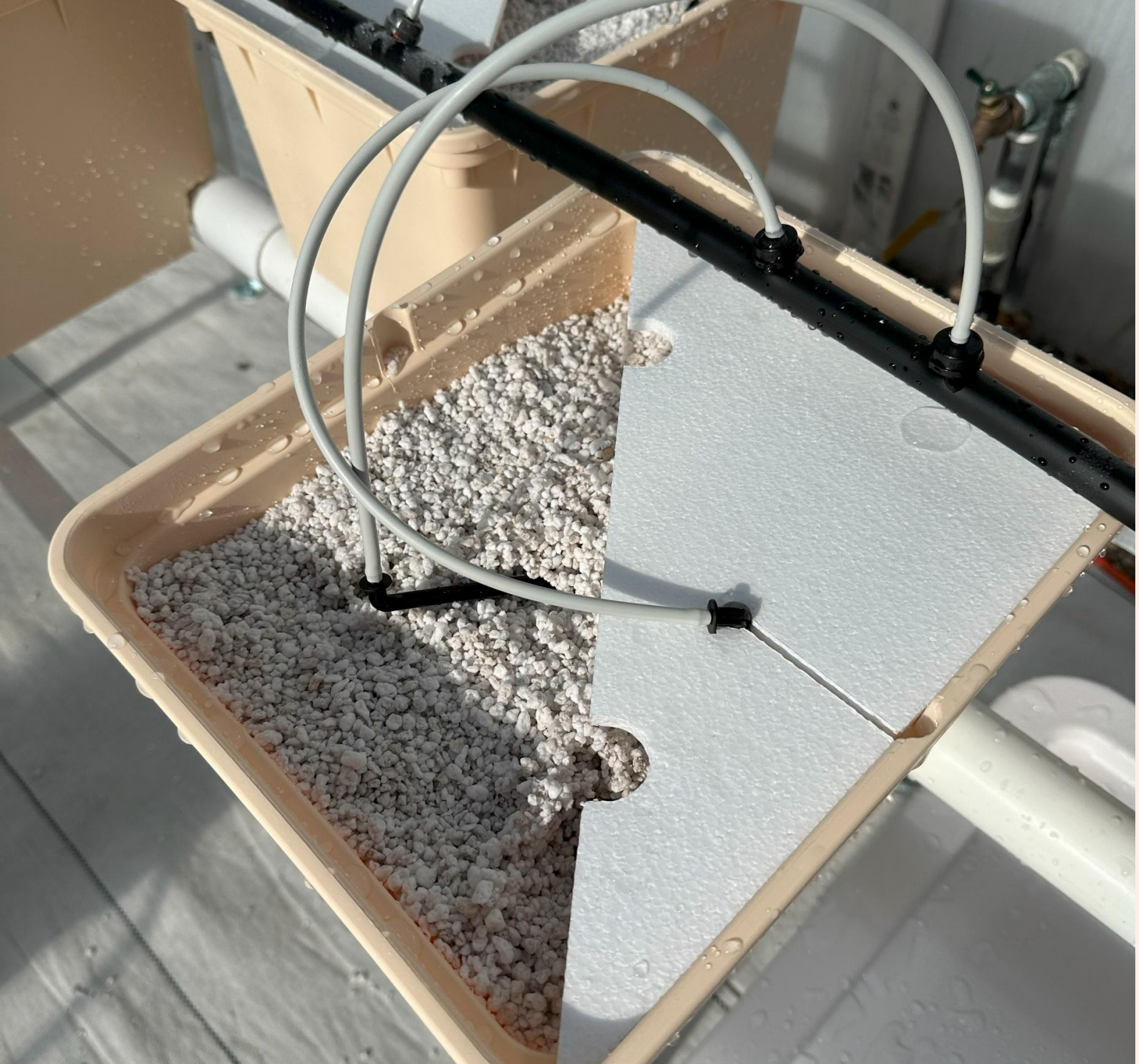

Hydroponic Substrate

Common Substrates

- Perlite is a light-weight volcanic rock that comes in various grades (fine or coarse)
- Perlite has good drainage and is easy to use individually or can be added in loose mixes
- Perlite is initially very dusty, can turn green from algae, and can be difficult to reuse due to entanglement with plant roots

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Hydroponic Substrate

Common Substrates

- Vermiculite is a light-weight mineral that comes in various grades (fine or coarse)
- Vermiculite is easy to handle and often added in loose mixes to improve moisture retention
- Vermiculite is also commonly used to cover seeds during germination

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Hydroponic Substrate

Common Substrates

- Clay pebbles, Hydroton, or LECA (lightweight expanded clay aggregate)
- LECA has very low bulk density thereby useful to fill large containers without being too heavy
- LECA has excellent drainage and can be cleaned and reused

Hydroponic Substrate

Substrate Characteristics

- The most important characteristic of substrate to consider is the water holding capacity (WHC)
- WHC is the amount of water a substrate can soak up and retain
- WHC determines the amount and duration of moisture available to plant roots

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Hydroponic Substrate

Substrate Characteristics

- For hydroponic substrate, WHC is typically the inverse of air porosity
- Air porosity is the pore space within the substrate that is filled with air (oxygen)
- Air porosity is important for root respiration, drainage, and fertigation frequency

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Useful Substrate Characteristics for Hydroponic Plant Production

Common Substrates	WHC	Air porosity	Nutrient charge	Reuse	Uniformity	Debris
Rock wool	high	low	none	no	yes	minimal
Coco coir	~medium	~medium	some	compost	no	yes
Vermiculite	~medium	~medium	minimal	compost	no	yes
Perlite	low	high	minimal	yes	no	minimal
LECA	very low	very high	minimal	yes	no	minimal

Hooks

Hydroponic Substrate

Substrate Characteristics

- Nutrient charge refers to essential elements that are present due to organic material
- Reuse refers to the ability to use the substrate for more than a single crop cycle
- Uniformity refers to the consistency in size, shape, and handling

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Useful Substrate Characteristics for Hydroponic Plant Production

Common Substrates	WHC	Air porosity	Nutrient charge	Reuse	Uniformity	Debris
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Vermiculite	~medium	~medium	minimal	compost	no	yes
Perlite	low	high	minimal	yes	no	minimal
LECA	very low	very high	minimal	yes	no	minimal

Hooks

Hydroponic Substrate

Substrate Characteristics

- Debris refers to how messy the substrate is and the potential for particles to contaminate the solution
- *Conclusion: There is no perfect substrate!*
- But knowing these characteristics can make you a skilled hydroponic grower!

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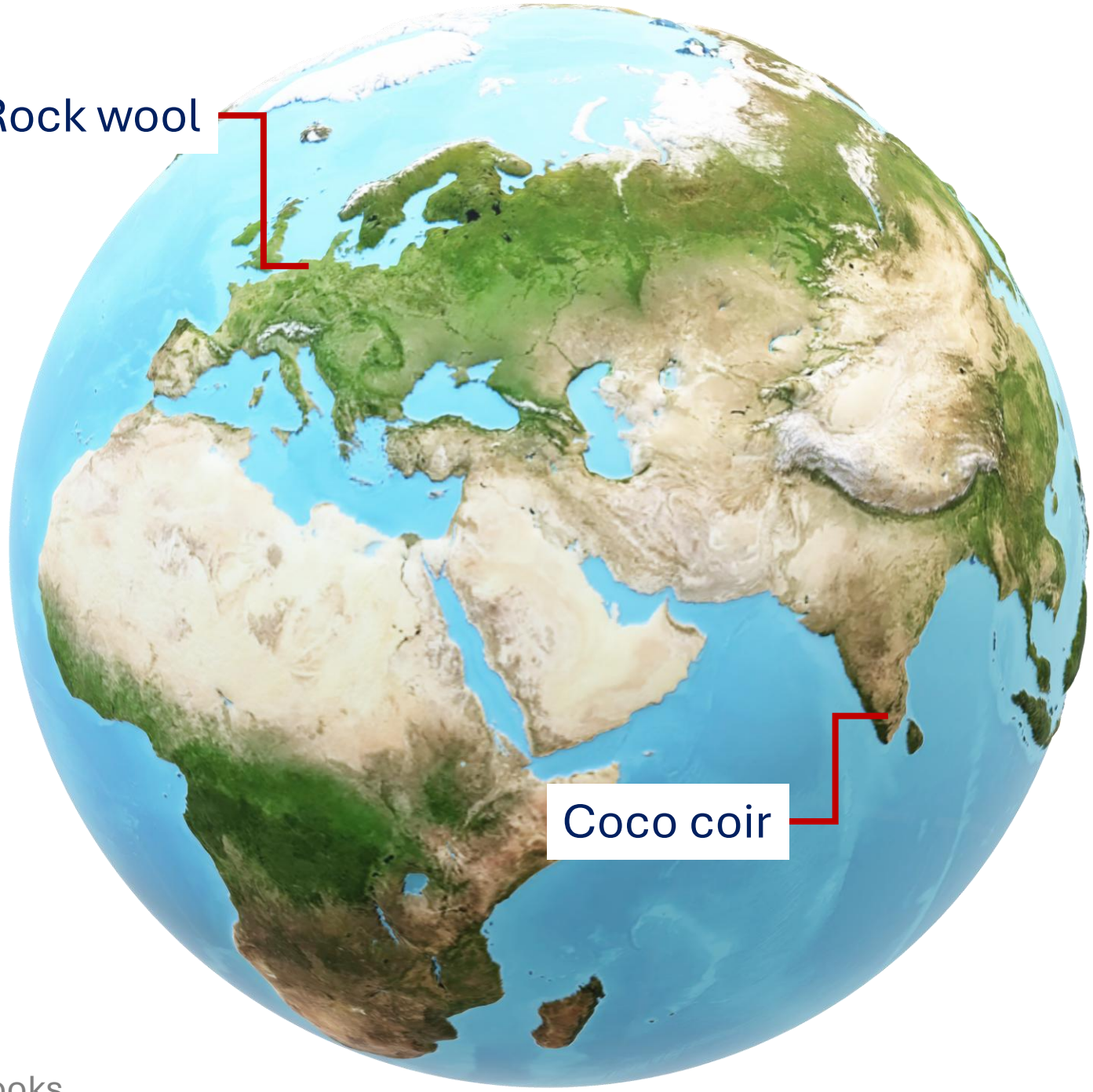

Hydroponic Substrate

Alternative Substrates

- *Why use alternative substrates?*
- Rock wool is primarily produced in The Netherlands and coco coir comes from India and Sri Lanka
- There is a growing need in the CEA industry for substrate that is renewable, locally sourced, or even produced on-site

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Hydroponic Substrate

Alternative Substrates

- Horticubes by Oasis
- Jute by Holland Bioscience
- Growcoons and Nygaia
- Sphaxx by Klassman Delman

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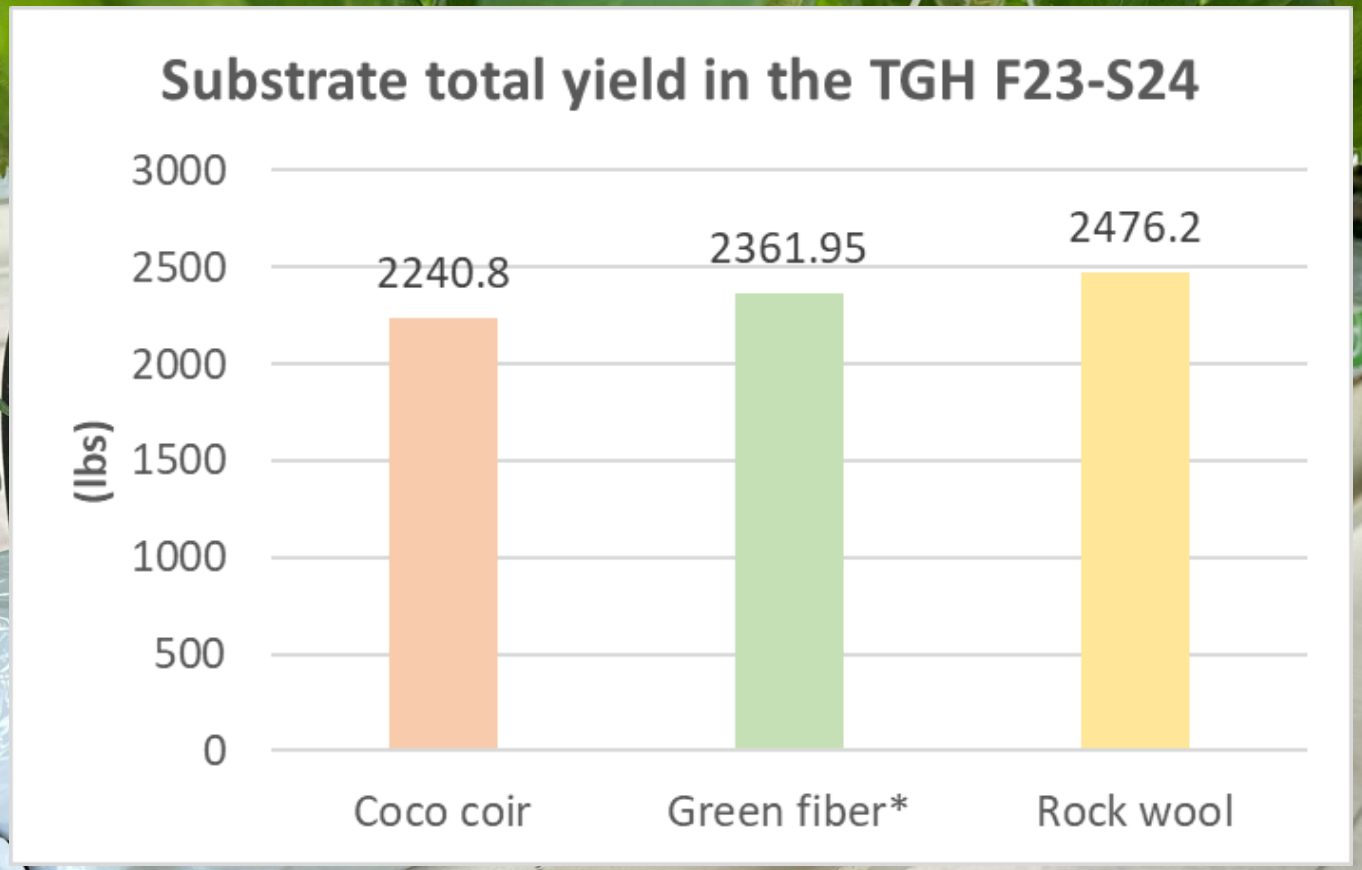
Hydroponic Substrate

Alternative Substrates

- Green fiber is a recycled wood-based substrate utilizing locally sourced material
- It was used in the Teaching Greenhouse alongside other substrates and performed well



GreenFibre®

Hooks

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Hydroponic Substrate

Alternative Substrates

- Bio-circular refers to using a waste stream as a resource to make a product
- Both CEA and traditional agriculture produce inedible biomass which results in agri-waste material
- *Can this agri-waste material be used to make a bio-circular substrate?*

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Hydroponic Substrate

Alternative Substrates

- There is potential for agri-waste to be used as sustainable and bio-circular substrate for CEA

- Examples of bio-circular substrate at the UA-CEAC:

    - Spent mushroom substrate (SMS)
    - Mycelium composite substrate (MCS)

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Hydroponic Substrate

Alternative Substrates

- Spent mushroom substrate (SMS) is the inedible material leftover from CEA mushroom production
- Mycelium composite substrate (MCS) uses agri-waste material and mushroom mycelium to bind and shape the substrate

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Hydroponic Substrate

Alternative Substrates

- Examples of bio-circular substrate to grow hydroponic crops such as tomato which can reduce waste!
- *Follow our project, Fungi Blocks for Fresh Crops, part of the Campus Sustainability Fund!*

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Hydroponic Substrate

- Alternative substrates offer exciting new ideas and new material for hydroponic growers

- Bio-circular substrates can use local agri-waste and be produced on-site, thereby reducing waste and improving the sustainability of hydroponic food systems!

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Hydroponic Plant Propagation

Propagation Overview

- Plant propagation refers to plant reproduction through several ways:
  - Cutting
  - Grafting
  - Seed
- Depending on the crop, all three are viable commercial methods of plant propagation

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Johnny's Selected Seeds

Hydroponic Plant Propagation

Propagation Overview

- For most crops, the primary method of propagation is by seed (heirloom or hybrids)
- In general, heirlooms have unique quality traits, but tend to be lower yielding and lack disease resistance
- Hybrids have vigorous and stable traits in the F_1 generation only

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Hydroponic Plant Propagation

Seed Propagation

- Purchase seed from reputable companies because many plant diseases are seed-borne
- Good quality seed have ~95% germination rate (GR)
- The more info/details provided about the seed the better!

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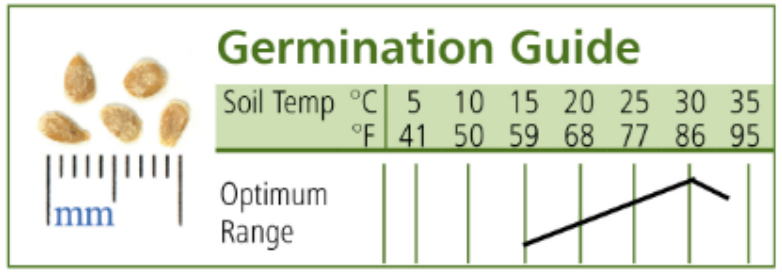
QUICK FACTS



LATIN NAME

Solanum lycopersicum

DAYS TO MATURITY ⓘ

78 Days

LIFE CYCLE ⓘ

Annual

DISEASE RESISTANCE CODES ⓘ

F , LM , TMV , V , PM

HYBRID STATUS ⓘ

Hybrid (F1)

PRODUCT FEATURES ⓘ

Geronimo

(F1) Tomato Seed

Firm, 8-10 oz. fruit is produced on vigorous plants with good balance. A perennial yield leader, Geronimo has stood up well to powdery mildew pressure in our high tunnel trials. High resistance to *Fusarium* wilt races 1, 2, leaf mold, tobacco mosaic virus, and *Verticillium* wilt; and intermediate resistance to powdery mildew. Indeterminate. Avg. 8,200 seeds/oz. Packet: 15 seeds.

Hydroponic Plant Propagation

Seed Propagation

- Check for descriptions of plant growth and fruit quality (e.g. indeterminate vs determinate)
- Check for disease resistances
- Check for unique features! (e.g. greenhouse, hydroponic, or photoperiod requirements)

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Hydroponic Plant Propagation

Seed Propagation

- Seeds can be treated, pelleted, coated, primed, raw, and Organic
- Can help with sanitation, handling, sticking, germination, etc…

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Hydroponic Plant Propagation

Seed Propagation

- Helpful questions to guide you when propagating by seed for hydroponics:
  - *How much growing space do you have?*
  - *What is your planting density?*
  - E.g. 4000 ft^2 / 2.5ft^2 per plant = 1600 tomato plants

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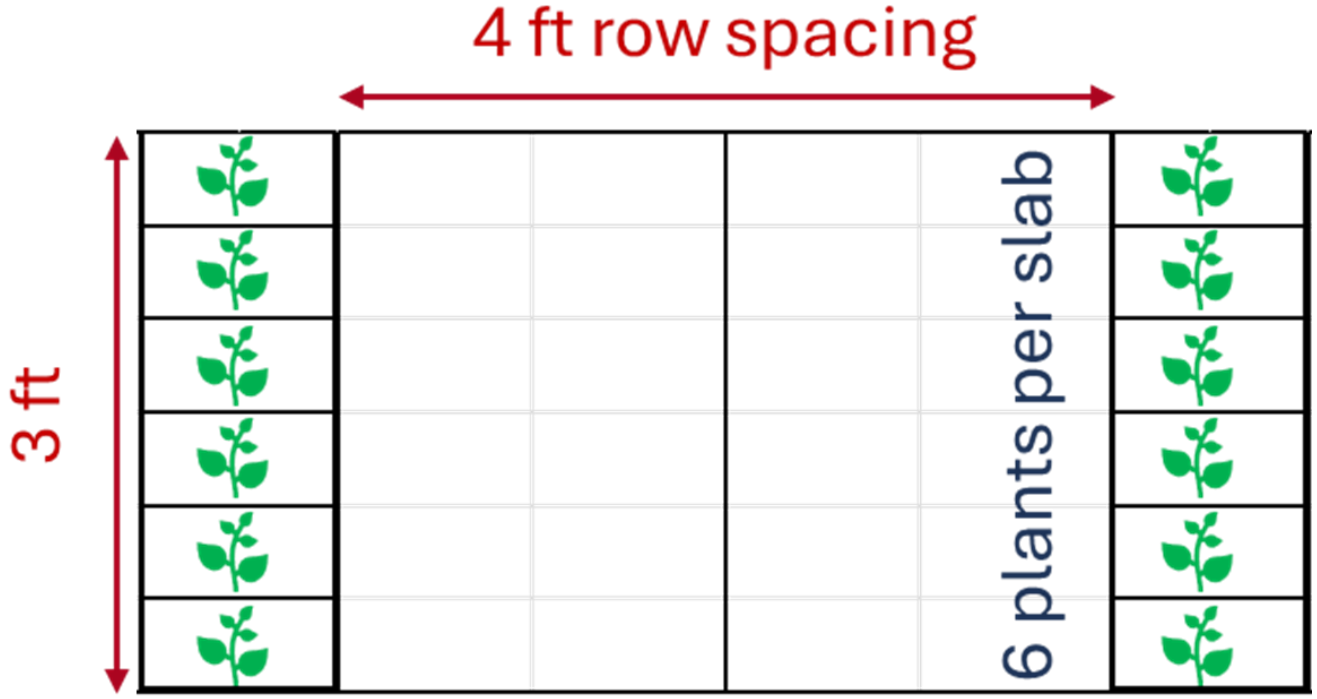
Hydroponic Plant Propagation



Seed Propagation

Teaching Greenhouse hydroponic vine crop planting densities:

- Tomato @ 6 plants per slab = 0.4 plant/ft^2 or 4.3 plants/m^2
- Pepper @ 5 plants per slab = 0.33 plant/ft^2 or 3.6 plants/m^2
- Cucurbits @ 4 plants slab = 0.27 plant/ft^2 or 2.9 plants/m^2

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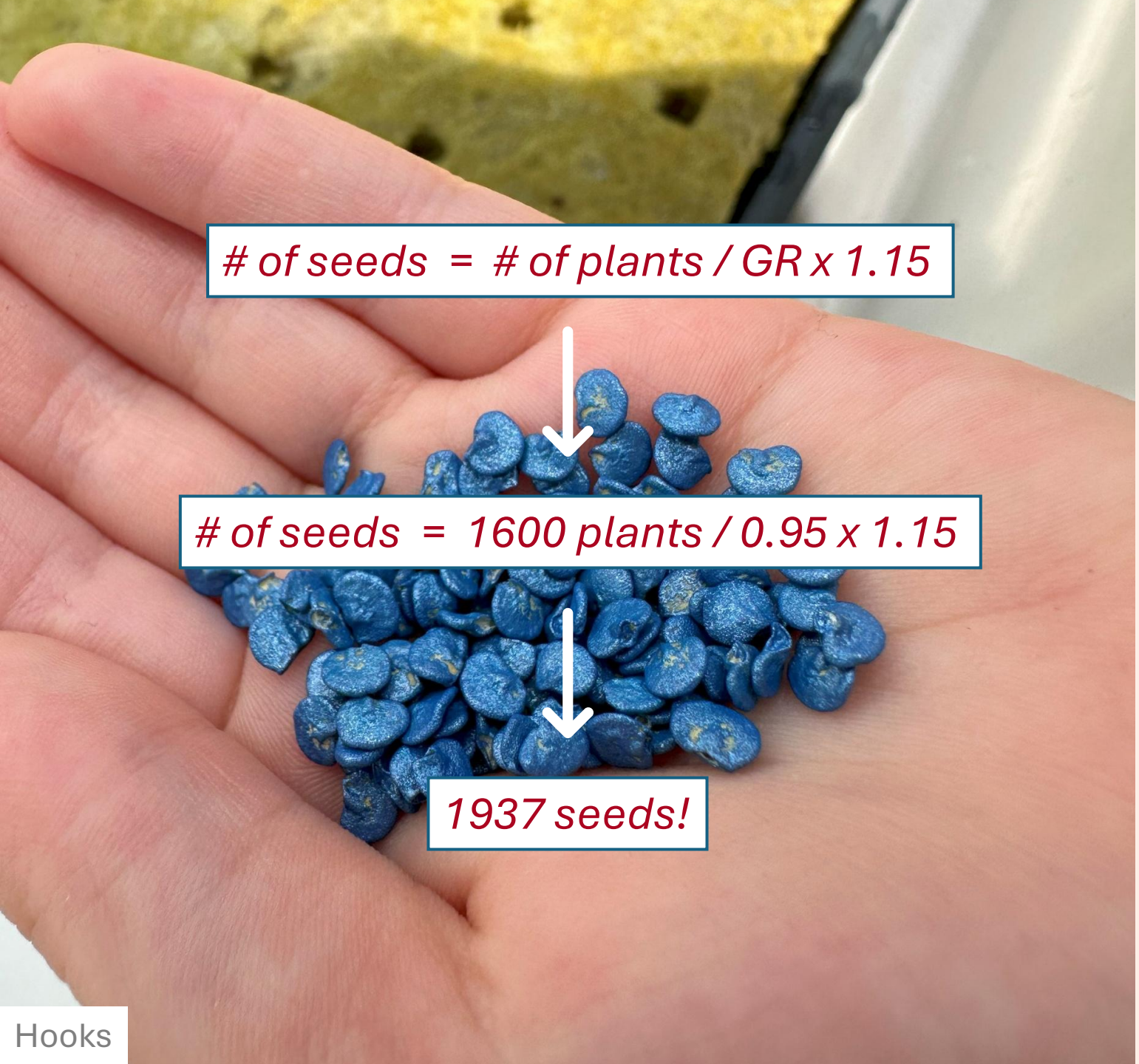

Hydroponic Plant Propagation

Seed Propagation

- Still need to calculate how much seed to buy because each seed is not *100%* guaranteed to be a plant!
- Need to account for the germination rate (GR), error, and selection (an extra ~15%)
- *If I need 1600 tomato plants to fill the Teaching Greenhouse, how many seeds do I sow?*

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Hooks

Hydroponic Plant Propagation

Seed Propagation

- You are ready to sow seed! Don't forget to get the gear!
  - Trays
  - Substrate
  - Seed
  - Forceps
  - Spray bottle
  - Humidity domes
  - Labelling supplies
  - Cleaning supplies

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Hydroponic Plant Propagation

Seed Propagation

- First, be sure to sanitize hands, surfaces, and tools
- Recommend soap and water to scrub, then rinse, followed by a surface spray of hydrogen peroxide (3%) or Zerotol (1%)
- Bleach can be used to disinfect but use cautiously as it can leave salty residue!

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Hydroponic Plant Propagation

Seed Propagation

- Label trays first to stay organized and prevent confusion/mistakes
- Recommend recording the crop, variety, and sowing date
- Can use the sowing date as “Day 0” and subsequent days as DAS 1, 2, 3… (days after sowing)

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Hydroponic Plant Propagation

Seed Propagation

- 1020 trays are recommended to use for hydroponic seed propagation
- 1020 trays come with or without drainage slits
- A common practice is the double tray method (tray with drainage placed in a tray without drainage)

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Hydroponic Plant Propagation

Seed Propagation

- All hydroponic substrate needs to be pre-soaked before sowing seed
- Recommend using tap water to shower overhead and thoroughly soak and flush the substrate to ensure uniform moisture

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Hydroponic Plant Propagation

Seed Propagation

- You are ready to sow seed!
- To sow by hand, make sure hands are clean and dry, and be methodical to avoid missing cells
- For most hydroponic crops, sow one seed per well

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Hydroponic Plant Propagation

Seed Propagation

- The last but most important step is to ensure the seeds have <u>100% moisture</u>
- A spray bottle with tap water is sufficient
- Recommend using 1% Zerotol or 3% H_2O_2 for the added benefit of sanitizing the seed!

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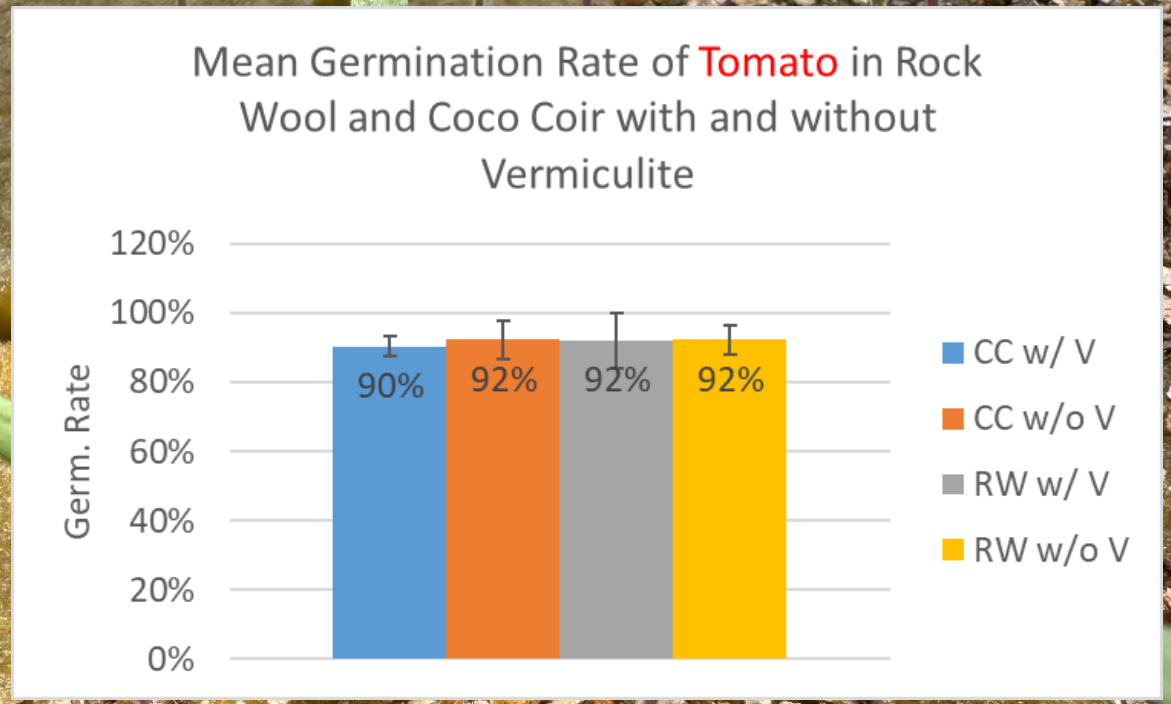
Hydroponic Plant Propagation

Seed Propagation

- Vermiculite is commonly used in hydroponic propagation to cover the seeds and keep moisture close
- Can also provide friction to help remove the seed coat during emergence
- However, germination and emergence can be successful without vermiculite!



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Hydroponic Plant Propagation

Seed Propagation

- Alternatively, a humidity dome can be used to create a very humid environment for the seeds

- Use briefly (1-3 days) and with caution due to the potential for extreme heat inside the humidity dome!

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Hydroponic Plant Propagation

Seed Propagation

- The goal is clean, efficient, and moist conditions for hydroponic seed propagation
- Seeds can germinate using tap water *or* 1/2x nutrient solution
- Generally warm conditions (~86F or 30C) speed up germination

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Pure Hydroponics, Maximum Yield, Bootstrap Farmer

Hydroponic Plant Propagation

Seed Propagation

- After sowing, place trays in a hydroponic propagation system
- Examples of propagation systems include:
  - Recirculating channels
  - Flood tables
  - Misting benches
  - Double tray method

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Hydroponic Plant Propagation

Review from last module:

- Clean, efficient, and moist conditions are needed for hydroponic seed propagation
- Seeds can germinate using tap water or 1/2x nutrient solution
- Generally warm conditions (~86F or 30C) speed up germination

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Hydroponic Plant Propagation

Seed Germination

- Germination occurs when the seed imbibes water which activates enzymes and respiration increases
- Moisture is the most critical factor for successful seed germination!

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Hydroponic Plant Propagation

Seed Germination

- Following germination, the radicle grows out from the seed in a downward direction due to gravitropism

- The radicle will establish the roots in the substrate and enable water and nutrient uptake by the plant

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Hydroponic Plant Propagation

Seed Germination

- Next, the hypocotyl grows out from the seed in an upward direction due to phototropism
- Then, the cotyledons unfold from the seed coat to absorb light
- The cotyledons serve as an initial energy boost to help the seedling grow

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Tegan, Omar, Lucjan, 2020

Hydroponic Plant Propagation

Seed Germination

- Etiolation can occur if seedlings are grown in the dark or without sufficient light
- Etiolation is the over-expansion of plant cells in “search” of light
- Etiolated seedlings have extended and weak hypocotyls which are not ideal!

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Hydroponic Plant Propagation

Seed Germination

- Emergence is the visible appearance of the young seedling from the substrate
- At this stage, ensure sufficient light and air flow are provided!
  - Allow fresh air to circulate indirectly
  - Target at least 12 DLI*

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Hydroponic Plant Propagation

Seed Germination

- Remember, the goal of CEA and hydroponics is optimized plant growth, even during the germination stage
- Strong hypocotyls, white roots, and vibrant green leaves are good signs that your seedlings are vigorous
- *“A good seedling gives good production”*

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Hydroponic Plant Propagation

Boosting and Transplanting

- Boosting is taking established seedlings and placing them in a larger substrate block
- Established seedlings have unfolded true leaves and roots penetrating the substrate
- True leaves have distinct morphology and primarily photosynthesize

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Hydroponic Plant Propagation

Boosting and Transplanting

- Rock wool or coco coir boost blocks can be placed on shallow trays that can hold 24 – 40 blocks

- Similar to seed sowing, label trays and thoroughly pre-soak the boost blocks with tap water

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Hydroponic Plant Propagation

Boosting and Transplanting

- Boosting simply involves placing an individual seedling/cell/plug into a boost block

- Boosting requires handling the seedlings so be sure to wash hands or wear gloves to prevent the spread of plant pathogens

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Hydroponic Plant Propagation

Boosting and Transplanting

- Boosting requires a gentle but firm touch to ensure the substrate makes good contact for the roots to grow
- Sometimes roots can be too long and can be pruned (Cucurbits!)
- For coco plugs, gently twist and squeeze the plugs while boosting

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Hydroponic Plant Propagation

Boosting and Transplanting

- At the boosting stage, half-strength (1/2x) nutrient solution is critical!
- Shoot and root growth is increasing along with photosynthesis, all of which require essential elements

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Hydroponic Plant Propagation

Boosting and Transplanting

- During the boosting stage, the seedlings should not touch or shade each other to prevent competition, tangling, and pest pressure
- Space out the seedlings to ensure optimal growth conditions for vigorous transplants

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Hydroponic Plant Propagation

Boosting and Transplanting

- If you do not space your boosted seedlings, then they will bolt for light!
- These transplants are too thin and tall, once separated they will fall over and break!

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Hydroponic Plant Propagation

Boosting and Transplanting

- These boosted seedlings are properly spaced and have strong stems and full leaves!
- Boosted seedlings are established when they have several true leaves, ~6 inches tall, and roots penetrating the substrate
- It's a good practice to check for root growth often!

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Hydroponic Plant Propagation

Boosting and Transplanting

- Once boosted seedlings are established, they are ready to be transplanted to the final production system!
- The focus of the transplant stage is to encourage lots of root and shoot growth so prune flowers if you see them

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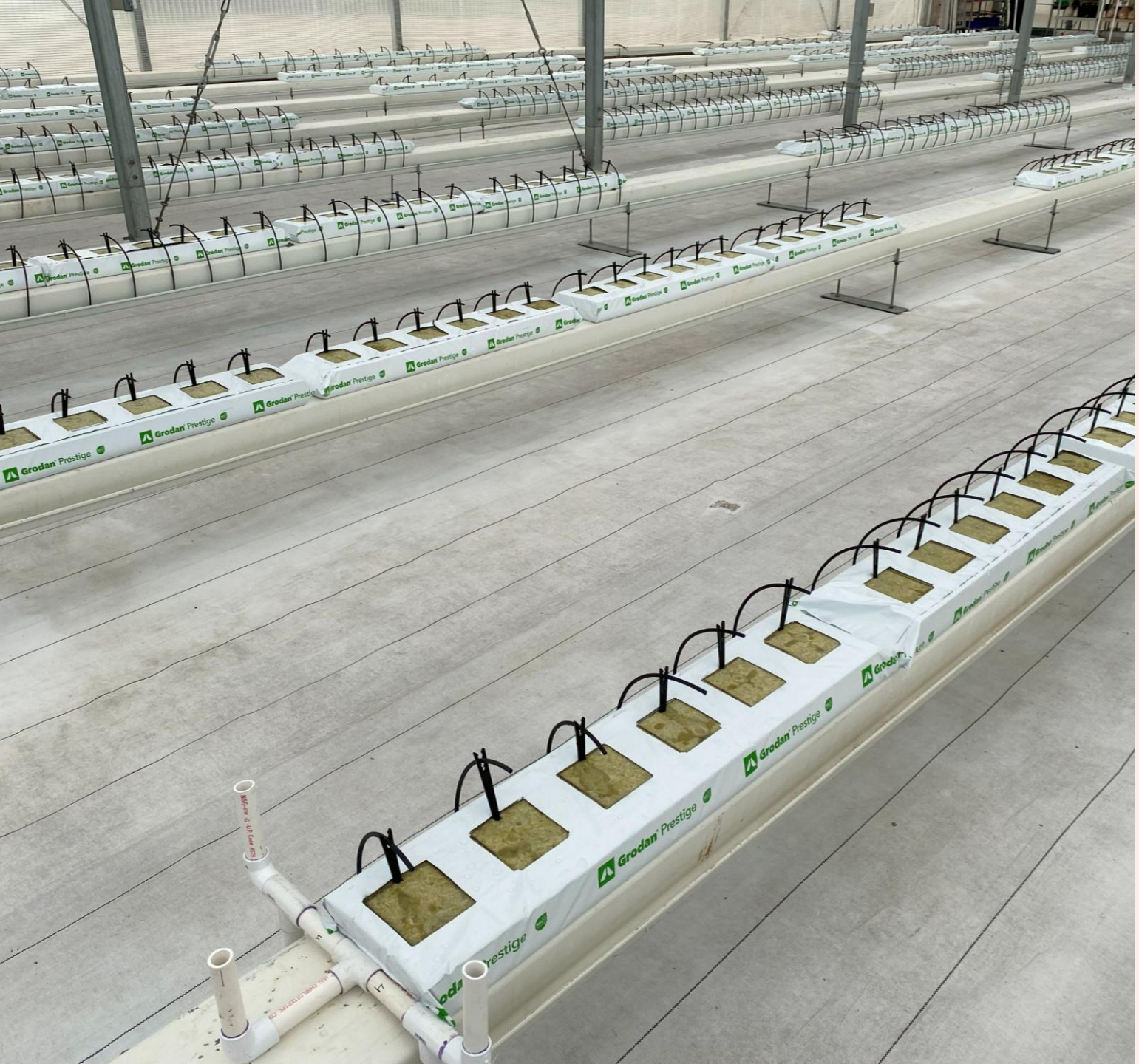

Hydroponic Plant Propagation

Boosting and Transplanting

- The final production system needs to be cleaned and prepared before transplanting
- For greenhouse hydroponic vine crops, lay down substrate slabs end-to-end on the gutters and cut openings on top of the slabs where the plants will go

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Hydroponic Plant Propagation

Boosting and Transplanting

- Install drip lines (1/4 inch) and stake them to the substrate
- Pre-soak the slab substrate by running tap water (no nutrients) through the drip lines until the bags are *100%* full

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Hydroponic Plant Propagation

Boosting and Transplanting

- Drainage cuts need to be made at the bottom of each slab
- Number and position of drainage cuts can vary, but the goal is uniform drainage to prevent pooling in the slab
  - Can cut the corners or between plants on one side or both sides

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Hydroponic Plant Propagation

Boosting and Transplanting

- Make the cut extend from the bottom of the slab around to the side of the slab for effective drainage
- Total length of the cut should only be about ~3 inches

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Hydroponic Plant Propagation

Boosting and Transplanting

- Now you are ready to transplant!
- Place boosted seedlings on slab cutouts according to planting density
- Stake one drip line to each block and push it far enough to contact the slab and hold the seedling block in place

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Hydroponic Plant Propagation

Boosting and Transplanting

- Keep the drip lines ~1 inch above the substrate to prevent roots from growing into the tubing
- Avoid unnecessary long drip lines that will interfere with plant care, harvesting, and maintenance

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Hydroponic Plant Propagation

Boosting and Transplanting

- Attach vine twine to the transplants to provide initial support as they rapidly grow
- Ensure a loose fit, don’t injure your transplants!
- *More information on vine twine and supporting crops in the next module!*

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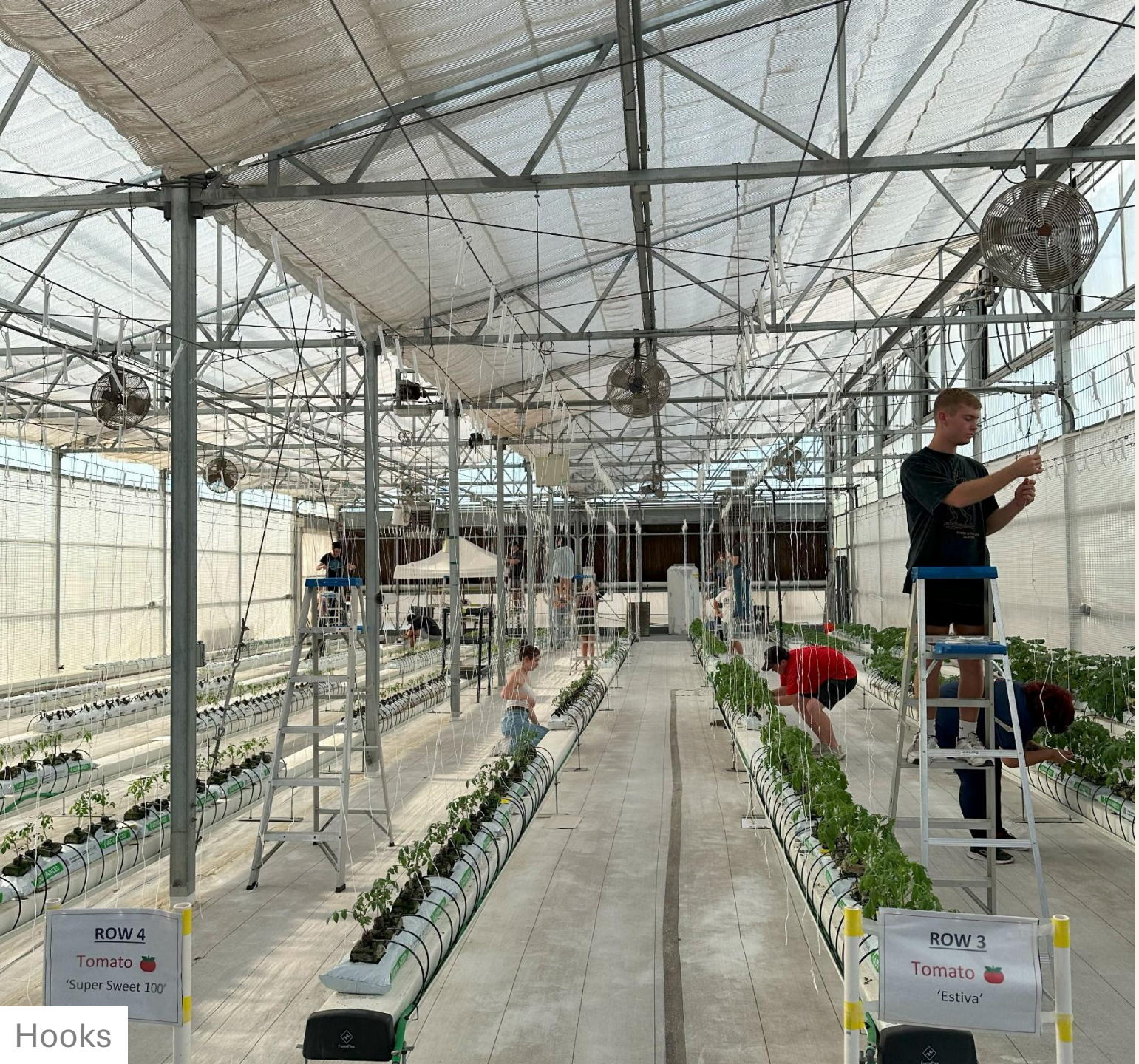

Hooks

Hydroponic Plant Propagation

Boosting and Transplanting

- Germination, Boosting, and Transplanting Timeline Guide:

Wk (Dy)	Tomato	Pepper	Cucurbits
0 (0)	Sow	Sow	Sow
1 (7)	Emergence		Emergence
2 (14)		Emergence	Boost
3 (21)	Boost		Transplant
4 (28)	Transplant	Boost	
5 (35)		Transplant	

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Module 2
Hydroponic Substrate and Plant Propagation

2026 Greenhouse Hydroponic Tomato Workshop with Dr. Triston Hooks

References

- *Resh, 2022, Hydroponic Food Production*
- *Principles of Plant Genetics and Breeding, 2012, Acquaah*
- *Johnny's Select Seeds* https://www.johnnyseeds.com
- *Hooks, 2022-2025, UA-CEAC Teaching Greenhouse and NFT greenhouse unpublished data*

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