Module 7
Tomato Flowers and Fruit

2026 Greenhouse Hydroponic Tomato Workshop with Dr. Triston Hooks

Outline

1. Tomato Flowers and Pollination
2. Fruit Pruning
3. Tomato Harvesting and Grading

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Tomato Flowers and Fruit

Review:

- Tomato trusses are branches that bear multiple flowers and fruit in a cascade pattern (oldest to youngest)
- A greenhouse hydroponic indeterminate tomato plant grows one truss per week

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- Tomato flowers first develop as buds protected by sepals
- Sepals open, followed by petals
- Open flowers are ready for pollination (anthesis)
- After ~2 days, petals close and then fall off

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- Tomato flowers are complete, having both male and female reproductive parts
- Male parts = Stamen (pollen, anthers, and filaments)
- Female parts = Pistil (stigma, style, and ovary)

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- Tomato flowers have a unique anther cone where the stamen and pistil are hidden inside

- Although the flower still needs to be stimulated for pollination to occur, the anther cone minimizes cross-pollination and promotes self-pollination

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Tomato Flowers and Pollination

- Some tomato varieties have flowers with an exposed stigma outside the anther cone which can allow for open/cross-pollination

- Some tomato varieties have mega flowers with multiple fused ovaries and can develop very large tomato fruits!

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- If you carefully remove the anther cone, you can see the stigma, style, and ovary
- Pollination occurs when pollen sticks to the stigma
- Fertilization occurs when a pollen grain develops a tube that penetrates the ovary

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

In order to grow a tomato fruit:

1. Flower must be pollinated during anthesis
2. Favorable environment for pollination and pollen tube development (<95F <85% RH)
3. Resources must be available for fertilization (water, nutrients, and carbohydrates)

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- Unpollinated/unfertilized flowers are dropped/aborted
- Regular pollination and successful fertilization are critical for consistent tomato production
- Therefore, active pollinators, conducive environment, and plentiful resources are essential!

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

How do you ensure flowers are pollinated?

- Tomato flowers require vibration to release pollen from the anther cone
- Airflow or physical interaction can stimulate this process but do not guarantee pollination…

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- Bumble bees are natural pollinators of tomato flowers
- Bumble bees “buzz” the anther cone to release the pollen
- They hold/bite the anther cone and leave a “bee kiss” which indicates the flower was pollinated!

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Koppert

Tomato Flowers and Fruit

Tomato Flowers and Pollination

- Bumble bee hives can be purchased and used in greenhouses
- One hive covers ~10k ft^2 and costs ~$300
- They typically contain a queen, workers, and brood (eggs, larvae, and pupae)

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Tomato Flowers and Pollination

- Keep the hive out of direct sun (recommended 50 – 86F)
- Bumble bees are most active during mornings and evenings
- Resilient to a wide range of conditions (wind, rain, low light, etc.)

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Tomato Flowers and Fruit

Tomato Flowers and Pollination

- *Bombus impatiens* (North American Eastern Bumblebee)
- Strong sense of smell and rely on UV-light to see
- Not aggressive and won't swarm, but can sting in self-defense!

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Tomato Flowers and Fruit

Fruit Pruning

- Once pollination is guaranteed, then you need to consider fruit pruning to achieve consistent and high quality yield

- Fruit pruning is managing the number of tomatoes that set on each truss

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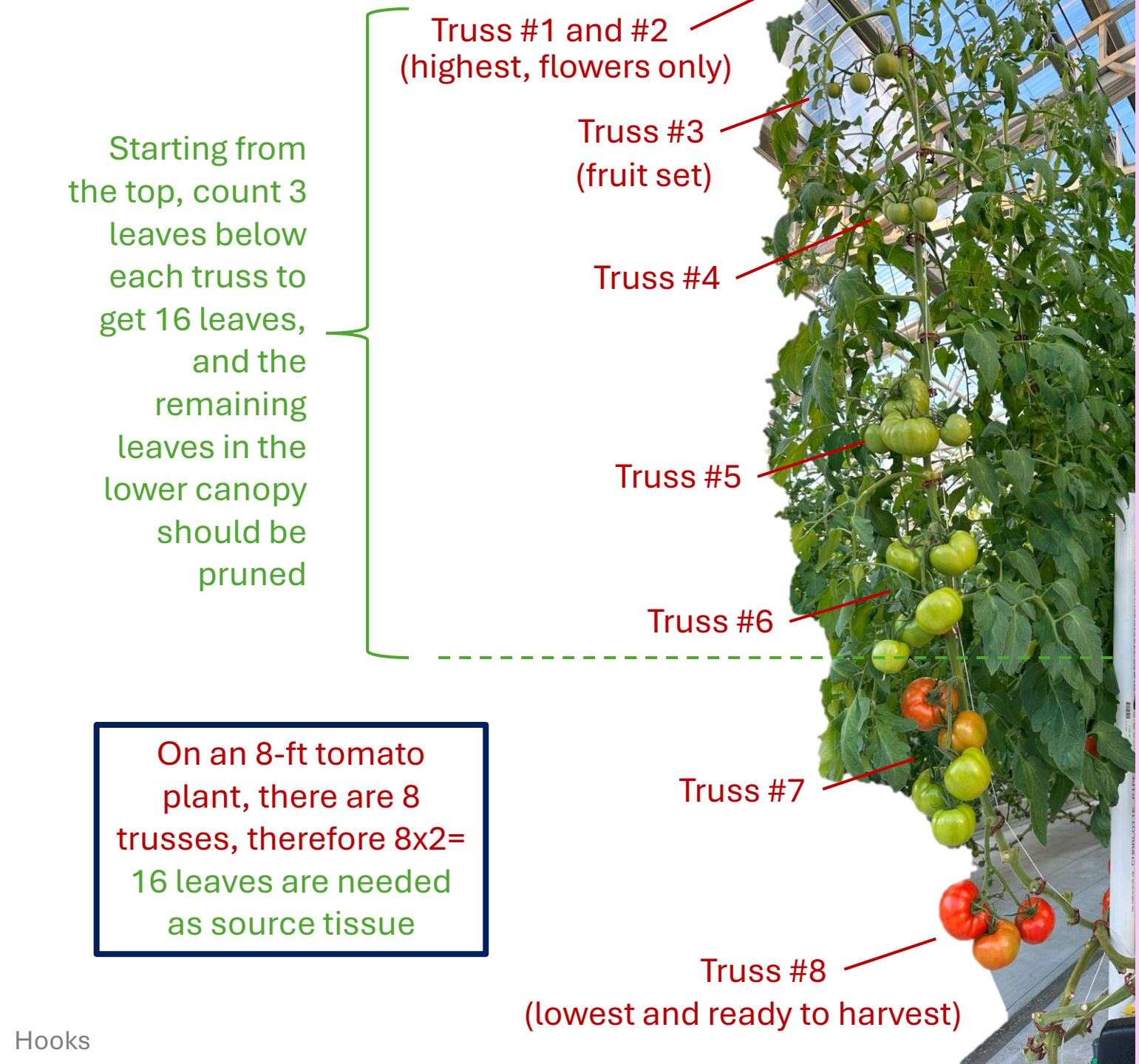
Tomato Flowers and Fruit



Fruit Pruning

- For sustained plant growth and fruit production, source and sink tissue need to be balanced
- In general, for every truss (sink tissue) on the plant, two mature leaves are needed as source tissue

Hooks

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Fruit Pruning

- This method of managing source and sink tissue is synergistic with plant steering and the weekly growth of tomato plants!

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Excessive fruit set (sink tissue) often requires more resources than the plant can physiologically provide which can slow down plant growth, fruit ripening, and lead to development problems…

Tomato Flowers and Fruit

Fruit Pruning

- *What happens if source and sink tissue are not balanced?*
- Too much source tissue = wasted resources
- Too much sink tissue = not enough resources
- The tendency is to allow the plant to produce more fruit, but more is not always better!

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Tomato Flowers and Fruit

Fruit Pruning

- Pruning excess fruit is an important part of plant steering that helps balance source and sink tissue

- *How do you prune excess tomato fruit?*

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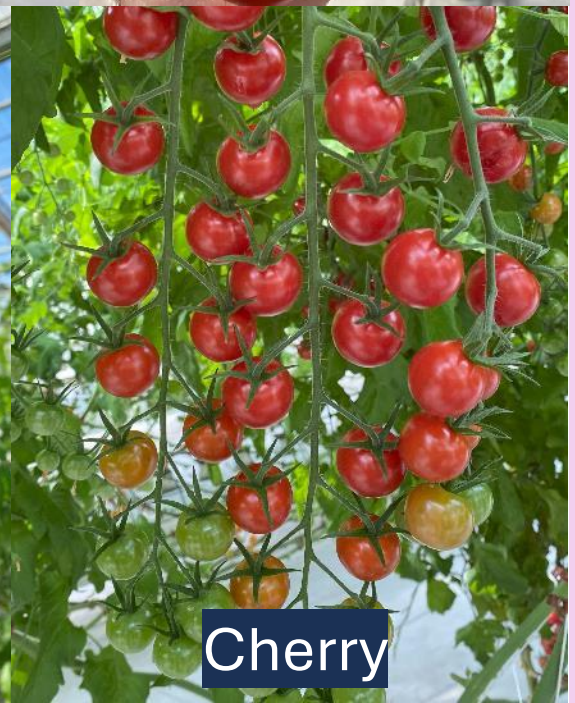

Tomato Flowers and Fruit

Fruit Pruning

- First, know your tomato type!
  - E.g. Beefsteak, TOV, Roma, Cocktail, Campari, Grape, Cherry, etc…
- The size of the tomato influences the ideal number of fruit each truss can support

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Expected Fruit per Truss

For greenhouse hydroponic indeterminate tomatoes

Tomato Type	Winter (Less than ideal)	Summer (Ideal conditions)
Beefsteak	2-3	3-4
TOV	3-5	5-7
Roma	4-6	6-8
Cocktail or Campari	6-10	10-14
Grape	8-12	12-16
Cherry	12-18	18-24

Fruit Pruning

- Use the provided numbers of expected fruit per truss to guide you in pruning excess tomato fruit
- Notice the ranges, a good grower is constantly assessing the plants and knows their capabilities/limitations!

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Almost!

Perfect!

Tomato Flowers and Fruit

Fruit Pruning

- The goal is to enable the plant to grow an ideal amount, size, and quality of fruit!
- Remember, more is not always better!
- *When and how do you prune excess tomato fruit?*

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Tomato Flowers and Fruit

Fruit Pruning

- *<u>When</u> do you prune excess tomato fruit?*
- Wait until most of the flowers in a truss have been pollinated and you can visually confirm fruit set
- Generally, this is the truss #3 or #4 at mid-canopy with green tomato fruit and some flowers still at the tip

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Tomato Flowers and Fruit

Fruit Pruning

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Tomato Flowers and Fruit

Fruit Pruning

- *<u>When</u> do you prune excess tomato fruit?*
- If you wait too long, you will waste the plant's resources and slow down fruit development…
- <u>Pruning excess tomato fruit is not wasteful, you will waste more if you don't!</u>

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Tomato Flowers and Fruit

Fruit Pruning

- *How do you prune excess tomato fruit?*
- Prune excess flowers/fruit from the tip/end of the truss
- Know your target e.g. ~10 fruit per truss for cocktail/campari

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Tomato Flowers and Fruit

Fruit Pruning

- *<u>How</u> do you prune excess tomato fruit?*
- For a truss with multiple branches, consider it a single large truss
- Prune branch tips and/or weakest branch(es) to maintain fruit target

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Tomato Flowers and Fruit

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Tomato Flowers and Fruit

Fruit Pruning

- *How do you prune excess tomato fruit?*
- It's not just about reaching your target fruit…
- Fruit should be uniform in size for consistent ripening/harvest
- For each truss, prune the smallest fruit relative to the biggest ones

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Tomato Flowers and Fruit

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Tomato Flowers and Fruit

Fruit Pruning

- Remember, the goal is balanced growth and consistent production for ~9 months

- Truss pruning helps steer the plant to produce its best and minimizes waste overall!

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Tomato Harvesting and Grading

- Harvesting produce is the final step in plant steering!
- It is not just beneficial for us, but also for the plant!
- Harvesting regularly helps balance source and sink tissue and maintains consistent production

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- When it comes to harvesting, remember the goal of CEA hydroponic tomato production is consistent, uniform, and balanced growth and production for an extended length of time…

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- So, how do you harvest? (it should be simple right?!)
  - At the right time
  - At the right frequency
  - At the right location

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Tomato Harvesting and Grading

- Tomatoes are climacteric, meaning they can ripen off the vine
- Ethylene gas is released and accelerates the ripening process

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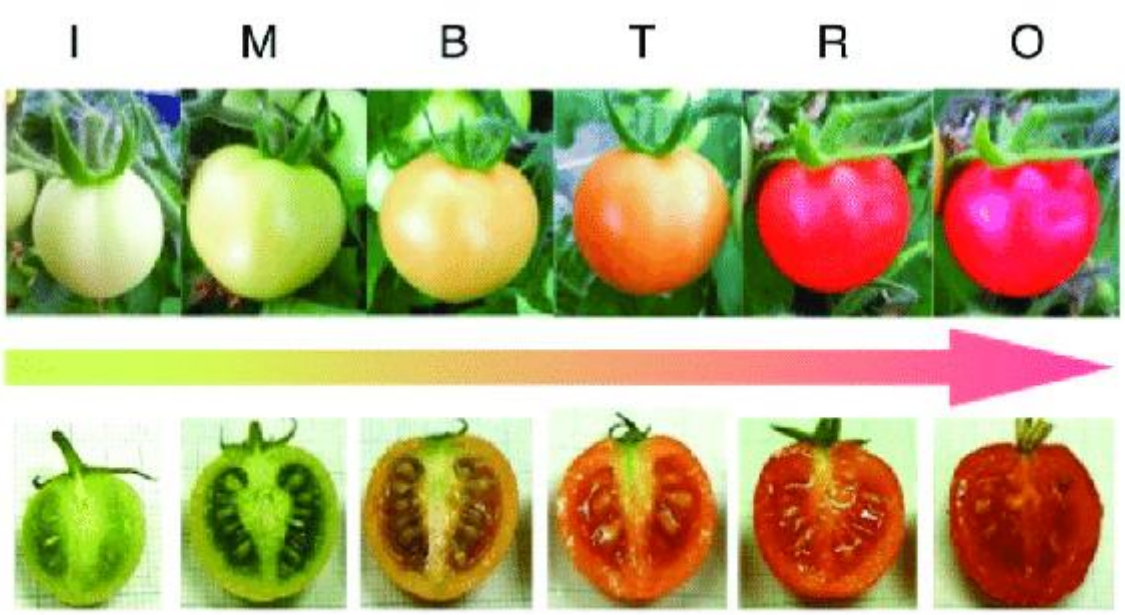

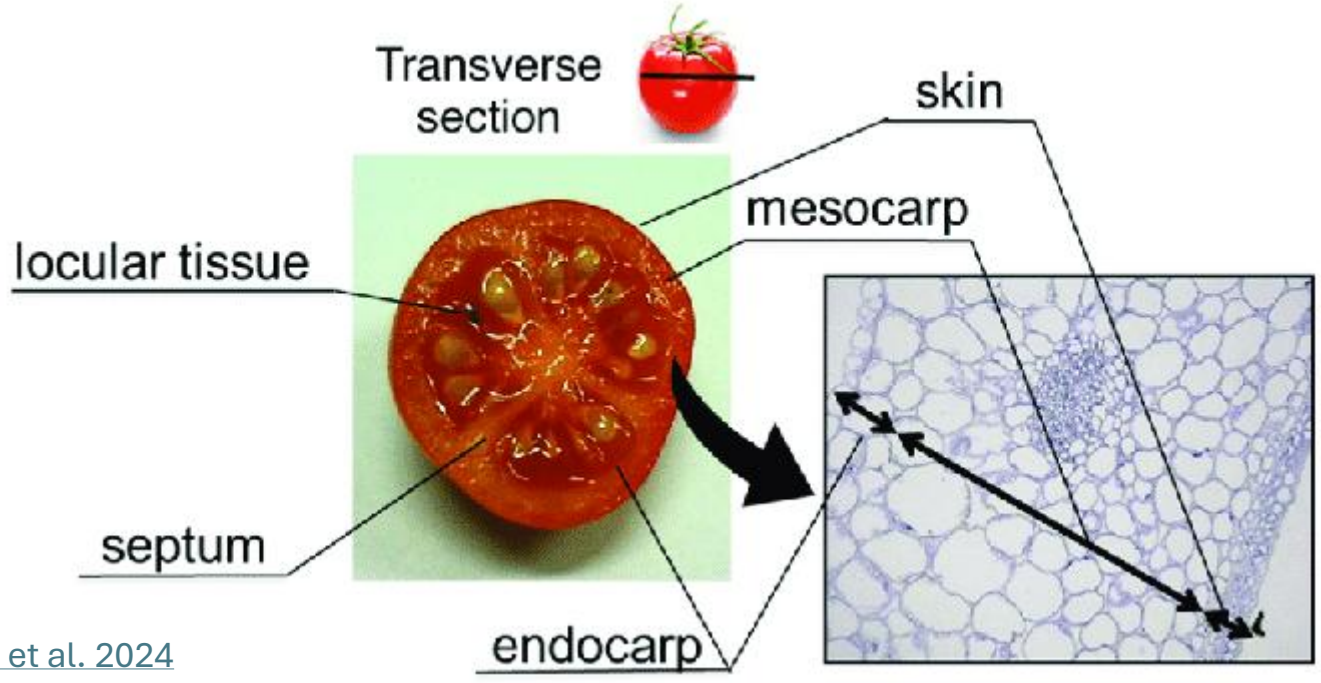

Wang et al. 2024

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Tomato Harvesting and Grading

- As the tomato fruit ripens, starches convert to sugars
- Cell walls break down and pectin is released
- Alkaloids (e.g. tomatine) decline and phytonutrients (e.g. lycopene) increase

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Tomato Harvesting and Grading

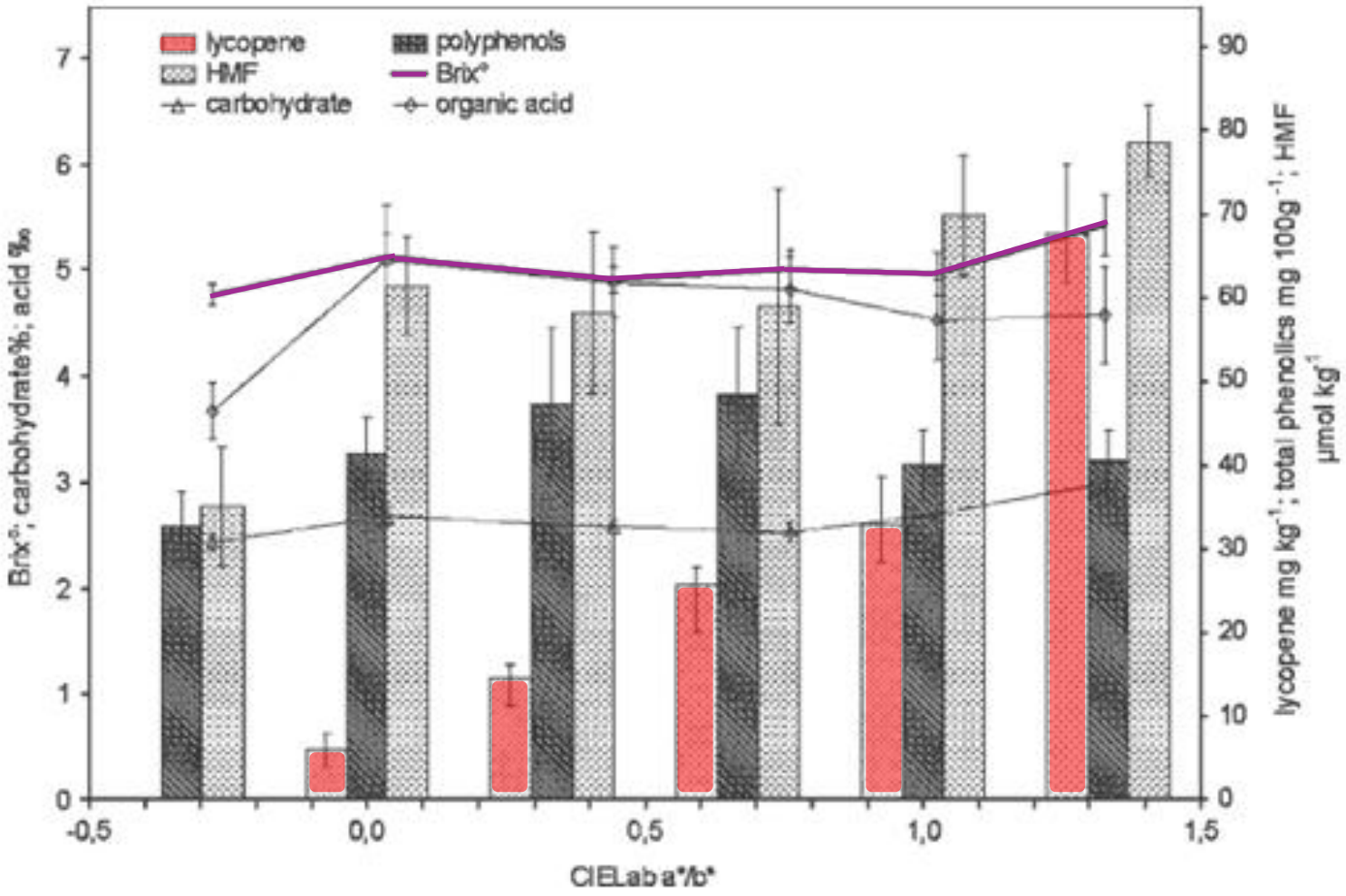

Fig. 1. Changes in the content of fruit components as a function of a*/b* ratio (mean ± SD; n = 12).

- BRIX is soluble sugar content, measured with a refractometer or digital BRIX meter
- BRIX increases as the tomato ripens, but not by much!
- Lycopene increases dramatically

Adapted from Tomato fruit quality

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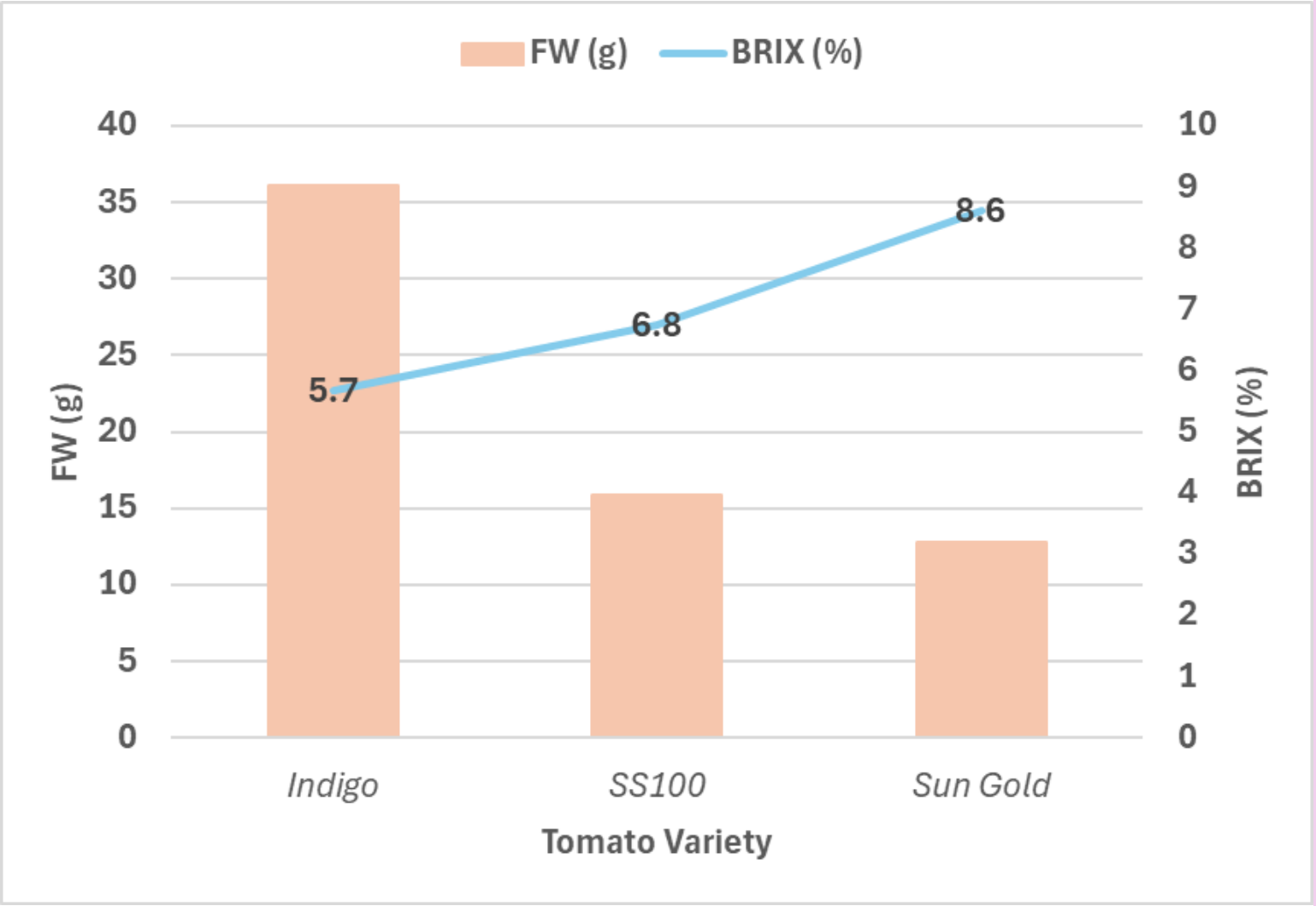

Tomato Harvesting and Grading

- Tomato sweetness is typically inversely related to tomato size
- In general, bigger tomatoes are less sweet, smaller tomatoes are more sweet

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Average grocery store tomato:
  - FW (g) ~200
  - BRIX (soluble sugar) ~3%
  - TA (titratable acid) ~0.3
  - BRIX / TA ratio ~10

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Tomato Harvesting and Grading

- Do greenhouse hydroponic tomatoes harvested “on the vine” taste better?

Tomato Type	Variety	Avg. TGH BRIX (%)
Beefsteak	Marbonne	4.4
TOV	Estiva	4.6
Campari / Cocktail	Indigo	5.8
Cherry	SS100	6.7
Cherry	Sungold	8.4

Hooks 2022-2025

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Tomato Harvesting and Grading

- In general, the more ripe a tomato fruit is, the more soft, sweet, and deep the color will be

- There is a “sweet spot” - an ideal time to harvest for the best tomato!

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- If you harvest early, the fruit is harder during transport and will ripen when it arrives
- Harvest too late, and tomatoes can be overripe and spoil
- Tomato color and timing are the primary guides for harvesting greenhouse tomatoes for your market!

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USDA

Tomato Flowers and Fruit

Tomato Harvesting and Grading

- USDA tomato ripening guide (stages 1 – 6)
- “Breakers” show the first sign of color change (stage 2)
- Many grocery store tomatoes are harvested at stages 2 – 4
- For local “farmers markets” the Teaching Greenhouse harvests at stages 5 and 6!

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Harvest at the right time but also harvest at the right location, in the lower canopy of the plant
- Harvest indeterminate greenhouse hydroponic tomatoes each week!
- You can anticipate your weekly harvest by looking at the trusses

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TGH average yield data 2023-2024

Crop	plant/ft2	lb/plant/wk	lb/ft2/wk	lb/ft2/yr*	lb/TGH/wk	lb/TGH/yr
TOV	0.40	1.0	2.5	12.0	1613	48,384
Cherry Tomato	0.40	0.3	0.6	3.0	403	12,096
Jalapeno	0.33	0.25	0.75	2.5	336	10,080
Cucumber	0.27	2.10	7.88	16.8	2258	67,738
	TGH data 4032 ft2 producing for 7 mo (30 weeks)					

Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Average tomato yield for open field = 10.6 kg/m2 (2.2 lb/ft2)
- Average tomato yield for greenhouse hydroponic tomatoes for 9 months = 55 kg/m2 (11.3 lb/ft2)
- *Maureira et al., 2022 Evaluating tomato production in open-field and high-tech greenhouse systems*

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Hooks

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Tomato Harvesting and Grading

- The Harvest Zone is the lower canopy (1/3 of growing space) where leaves are pruned and ripe fruit are visible and easy to harvest

- Ideally, the lowest truss (#8) should be harvested each week to maintain balanced source and sink tissue

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Harvest most tomatoes by hand and break the knuckles with your thumb to keep the sepals on
- Prune and remove empty trusses with a clean cut close to the stem

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Tomato Harvesting and Grading

- Sepals can be removed from some tomato types, depending on the market
- Grape, cherry, and roma tomatoes are often sold with sepals removed
- Sepals can dry out quickly and puncture fruit!

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Store produce in a cool and dry location out of direct sunlight
- Post-harvest ripening can occur rapidly in warm, sunny areas with poor air-flow

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- After harvesting, tomatoes are graded by market standards
- Size, shape, color, and defects are all considered
- The goal is consistent market quality and preventing food safety issues

Tomato Grades and Standards | Agricultural Marketing Service (usda.gov)

Standards-for-Growing-FDA-Regulation

Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Food Safety is crucial for preventing foodborne illnesses and ensuring that the food we consume is safe and nutritious
- Basic examples in the TGH include washing hands before and after harvesting produce and keeping produce free from contact with the floor and substrate

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Cull: food safety issue such as split fruit, fruit cracking, BER, open wound, immature (toxic) or overripe (mushy), pest/pathogen, mutation, etc.

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Sometimes tomatoes are “imperfect” with cosmetic deformities/mutations
- Sometimes safe to eat but not always marketable…

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Tomato Flowers and Fruit

Grade A

Grade B

Tomato Harvesting and Grading

- Grade A: correct size, ripeness, and shape, no/minor cosmetic defects
- Grade B: too small, not ripe, odd shape, minor cosmetic defects
- Cull: food safety issue!

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Tomato Flowers and Fruit

Grade A

Grade B

Tomato Harvesting and Grading

- Grade A: correct size, ripeness, and shape, no/minor cosmetic defects
- Grade B: too small, not ripe, odd shape, minor cosmetic defects
- Cull: food safety issue!

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Consider your market!
- Processing, grocery store, farmers markets, food distribution hub, restaraunts, etc.

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Tomato Flowers and Fruit

Tomato Harvesting and Grading

- Consider packaging, individual or on-the-vine, marketing keywords, etc.

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Tomato Flowers and Fruit

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References

- *Dr. Merle Jensen and Patricia Rorabaugh, Pollination, Fertilization, and Bee Management*

- *Hooks, 2022-2025, UA-CEAC Teaching Greenhouse unpublished data*

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