Strategies for Growing High-Quality Herbs

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Outline

Production Goals
What to grow?
Propagation
Nutrient Solution
Growing Environment
- Temperature
- Light

Why culinary herbs?

Popularity Production Postharvest



Production Goals

Aesthetically pleasing
Quick production time
Good flavor

Basil
Thyme
Rosemary
Parsley
Mint
Tarragon
Dill
Oregano
Chives
Sage
Chervil
Lemongrass
Sorrell
Watercress

Cultivars

Flavor type

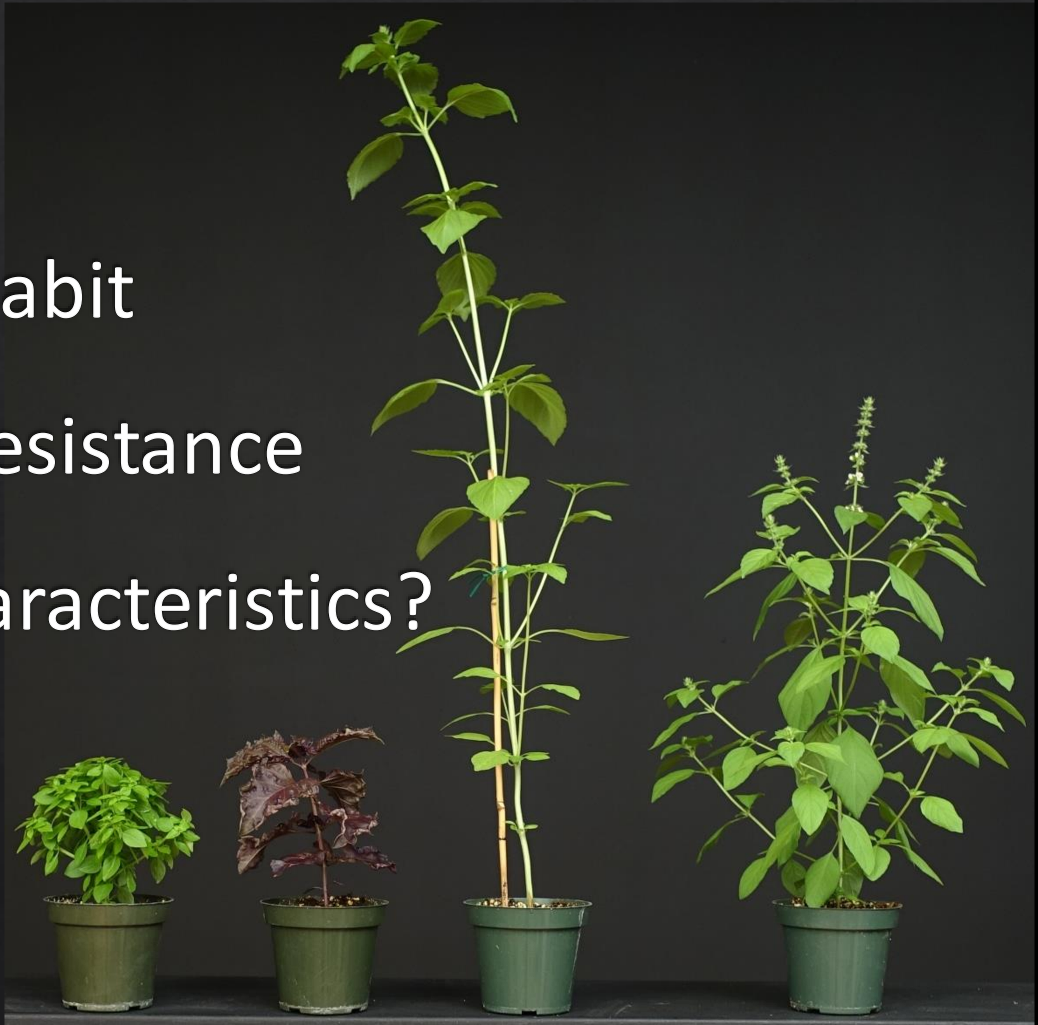
Color

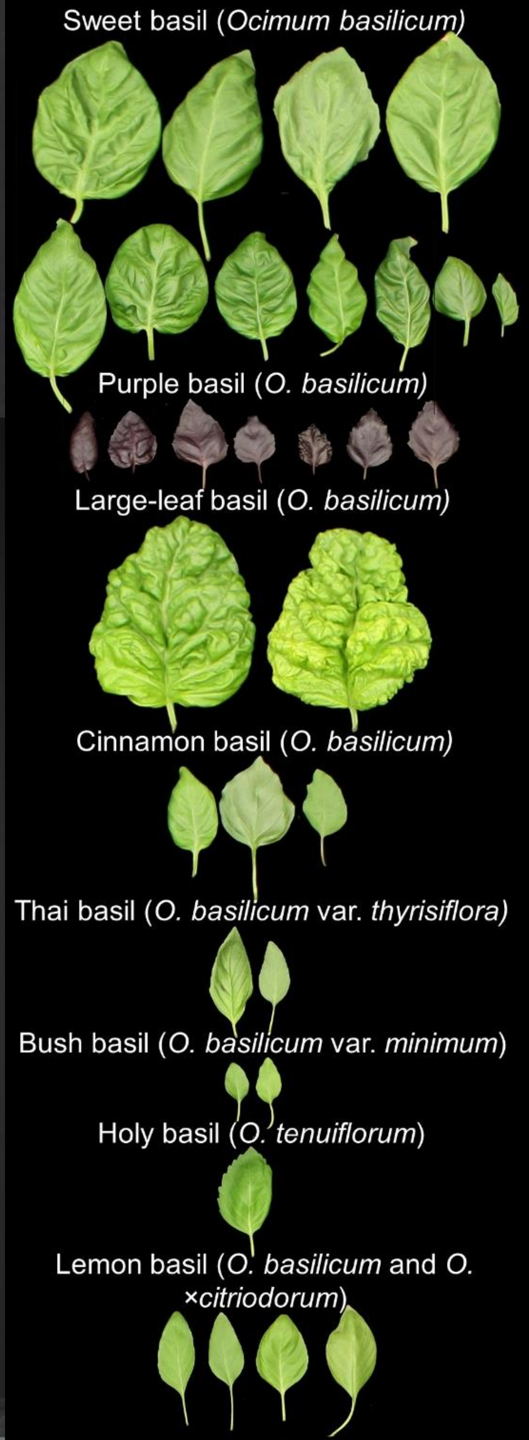
Leaf size

Growth habit

Disease resistance

Other characteristics?





Cultivar Selection

Cultivar	Fresh mass (g)	Dry mass (g)
Italian Large Leaf	50.6 ab	4.2 ab
Nufar	43.7 bc	3.6 b–d
San Remo	35.5 c–e	3.0 c–e
Napoletano	34.9 c–e	[redacted]
Genovese	34.3 c–e	[redacted]
Dwarf Bush	33.4 c–f	[redacted]
Super Sweet Chen	33.1 d–f	2.6 ef
Aroma 2	30.4 d–l	2.7 ef
Cinnamon	30.0 d–l	2.5 e–h

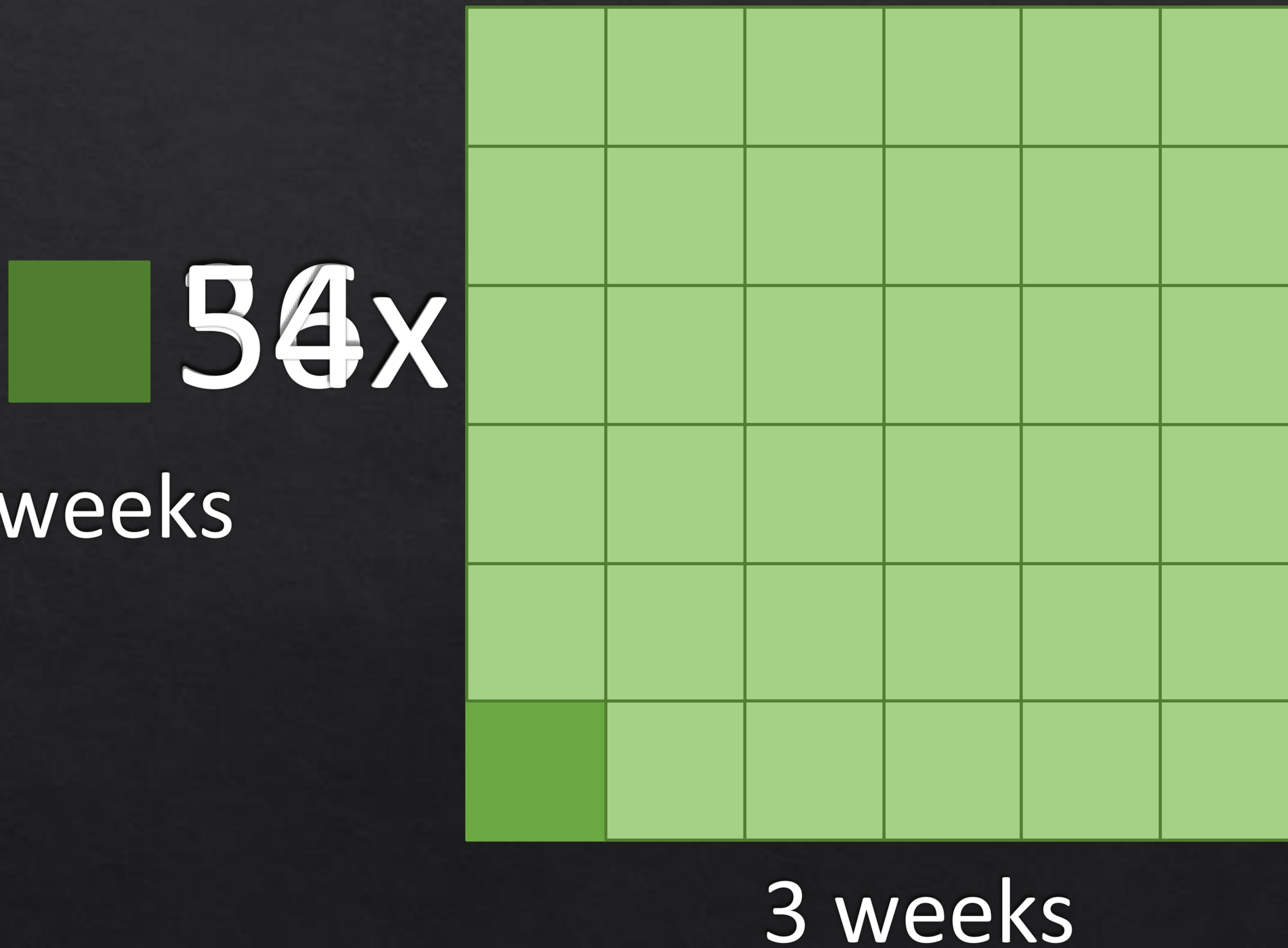
x 3.4

Cultivar	Fresh mass (g)	Dry mass (g)
Plenty	29.6 d–j	2.3 e–j
Dolly	22.6 g–l	1.8 f–k
Superbo	22.1 h–l	1.8 f–k
[redacted]	20.6 i–m	1.5 j–m
[redacted]	20.6 i–m	1.7 g–l
[redacted]	17.6 k–n	1.5 i–m
Genovese Compact	17.0 k–n	1.4 k–m
Christmas	15.9 l–n	1.3 k–n
Emily	15.0 l–p	1.3 k–n

(Walters and Currey, 2015)

Seedling Production vs. Finishing

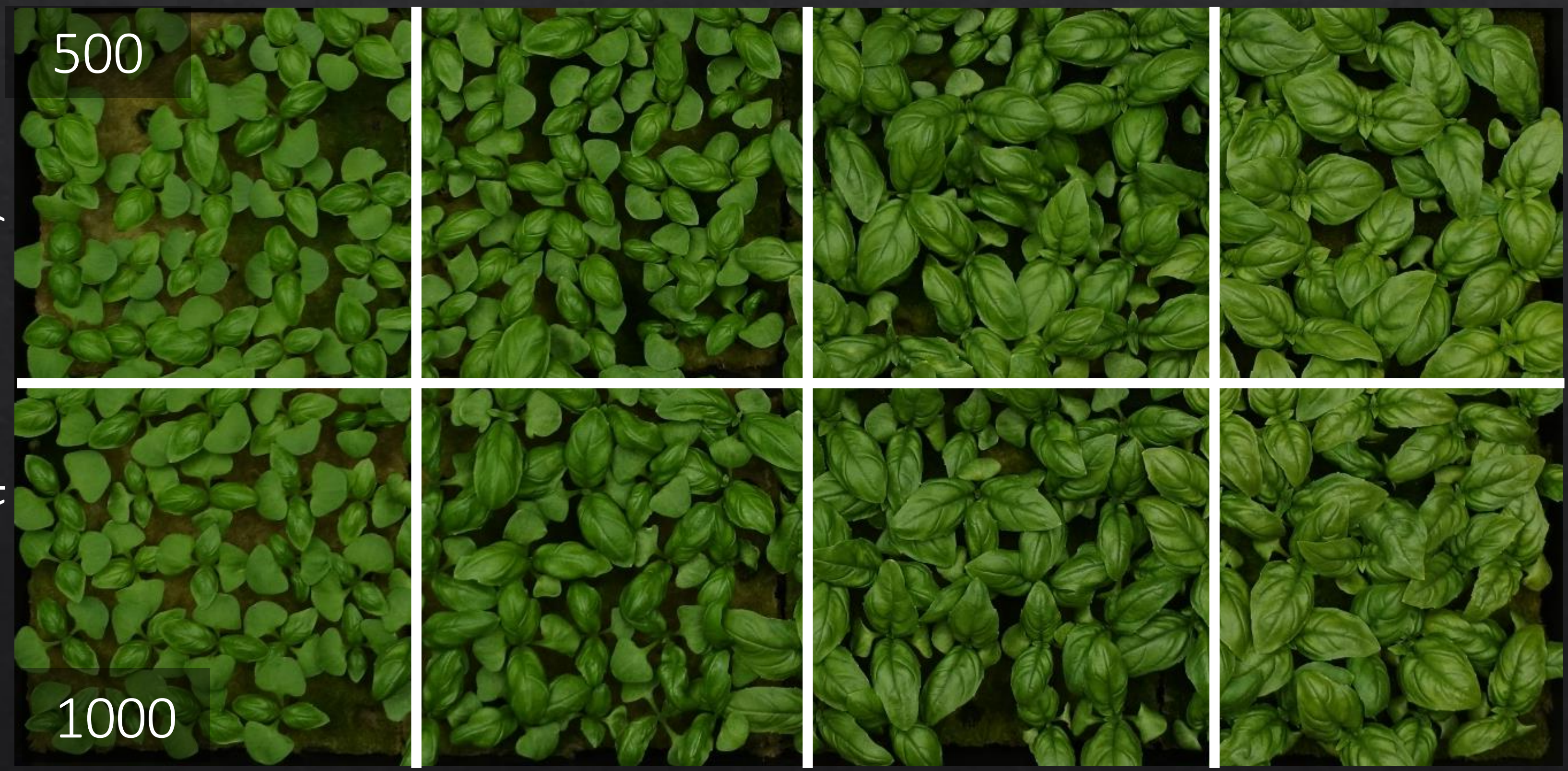
Seedling Production vs. Finishing



Sweet Basil 'Nufar'

2 weeks after sowing

Ambient CO_2 concentration ($\mu mol \cdot mol^{-1}$)



100 200 400 600

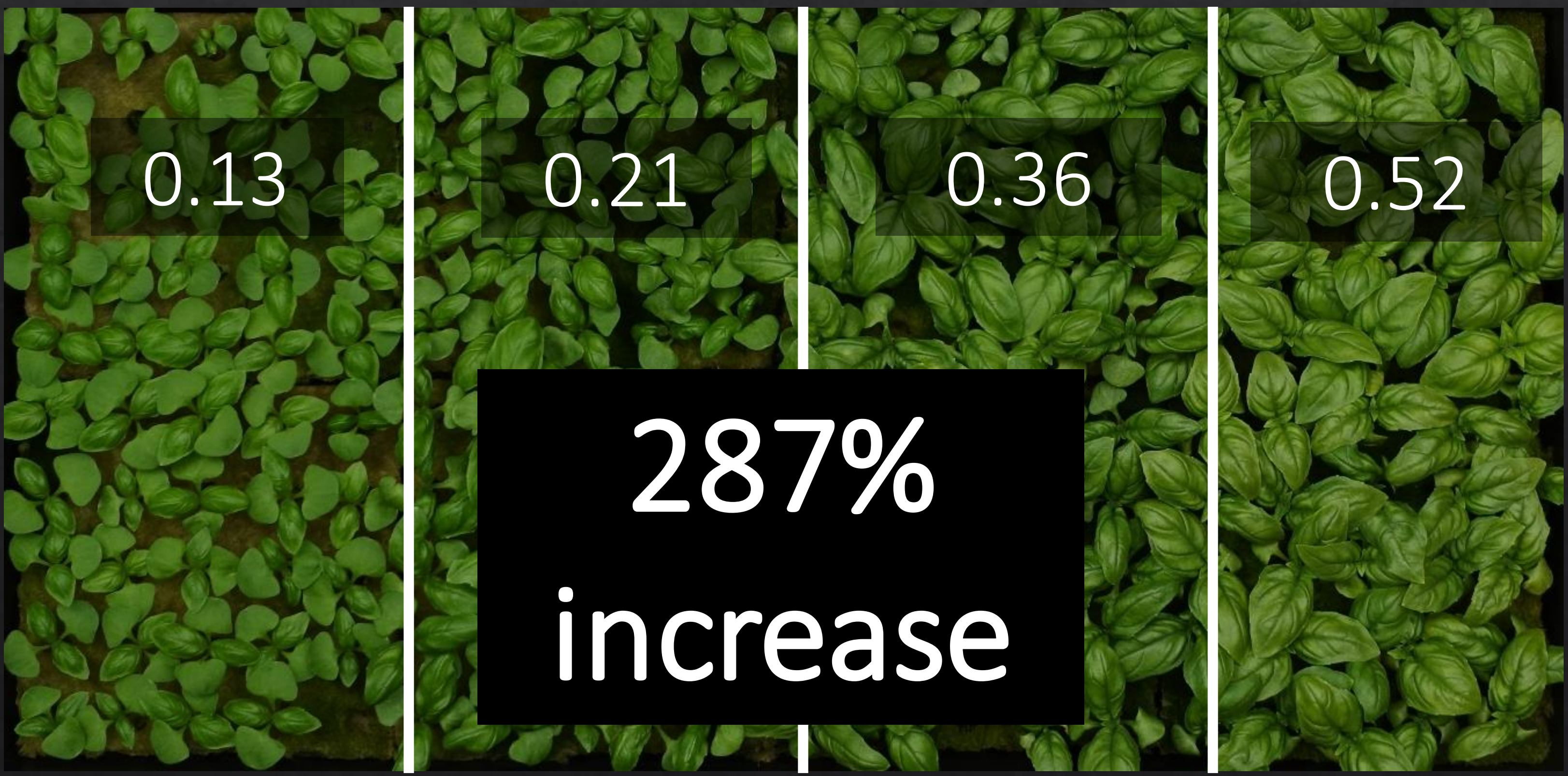
Target light intensity ($\mu mol \cdot m^2 \cdot s^{-1}$)

(Walters and Lopez, 2022)

Sweet Basil ’Nufar’

2 weeks after sowing

Shoot fresh mass (g)



100 200 400 600

Target light intensity (μmol·m^{2}·s^{-1})

(Walters and Lopez, 2022)

Sweet Basil ‘Nufar’

3 weeks after transplant

Seedling target light intensity ($\mu mol \cdot m^{2} \cdot s^{-1}$)

100	200	400	600

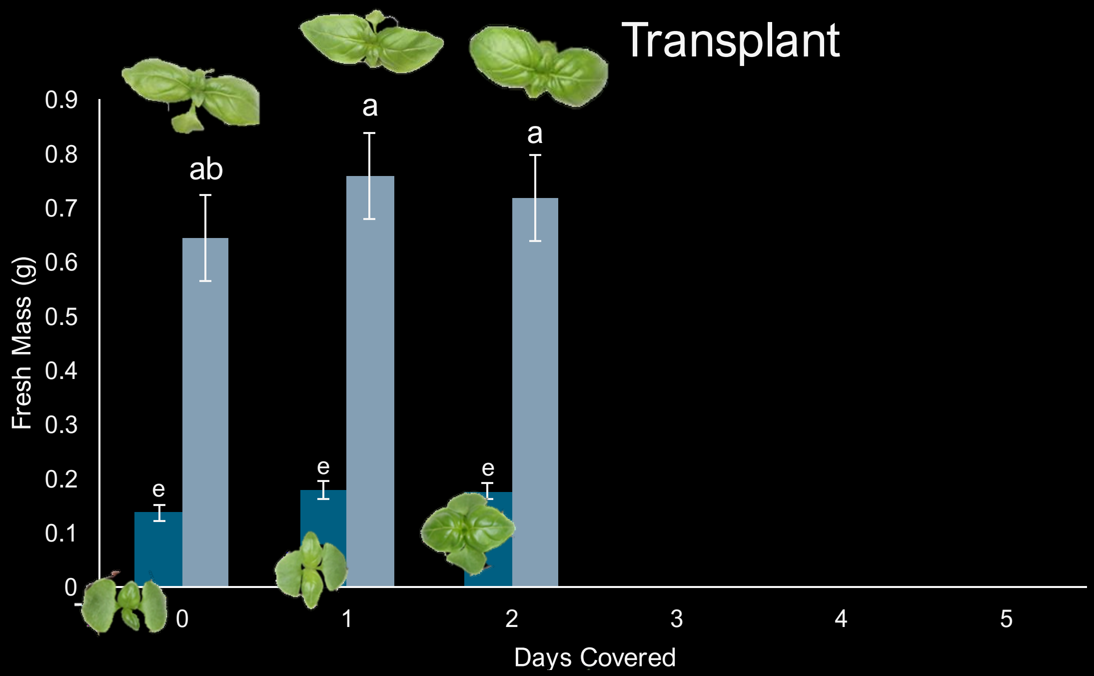
32	39	54	58

Fresh mass (g)

80% increase

(Walters and Lopez, 2022)

Should you germinate in the dark?



Sweet Basil 'Italian Large Leaf'

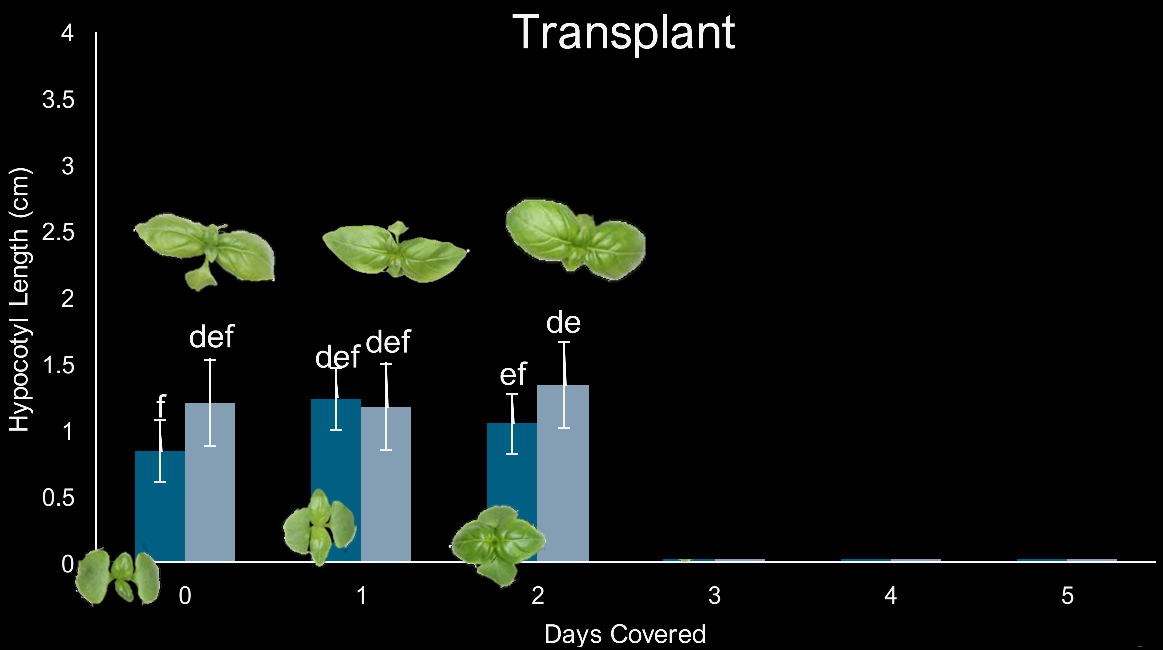
2 weeks after sowing

- 0 – 2 days = similar mass
- No affect under low light
- Mass trends persisted through finishing in a common environment

200 µmol·m^{-2}·s^{-1}
(DLI 11.8 mol·m^{-2}·d^{-1})

800 µmol·m^{-2}·s^{-1}
(DLI 46.8 mol·m^{-2}·d^{-1})

(Del Moro and Walters, Unpublished)



Sweet Basil 'Italian Large Leaf'

2 weeks after sowing

- 0 – 2 days = similar stretch
- Increased legginess when covered longer
- Hypocotyl length trends persisted through finishing in a common environment

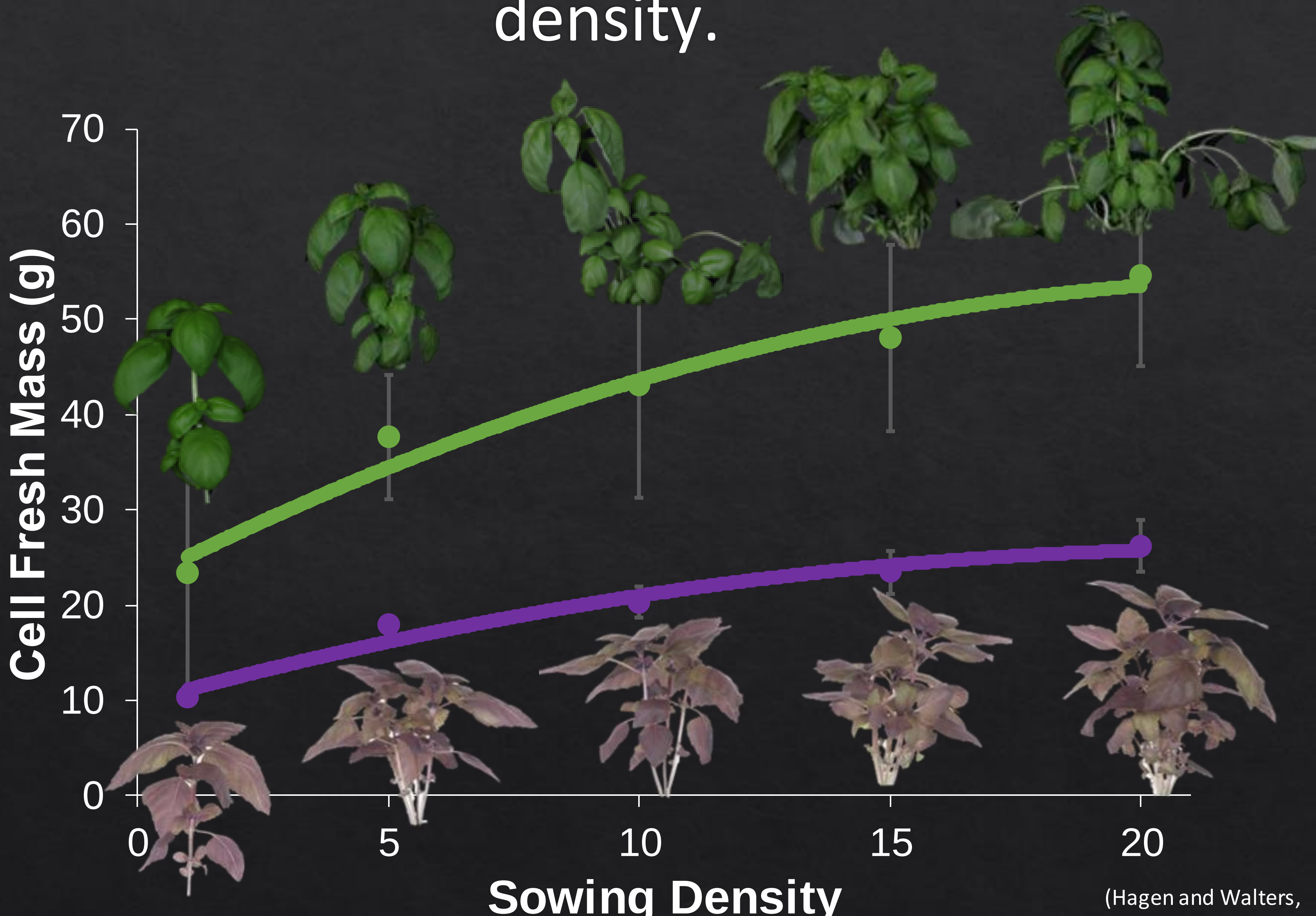
200 µmol·m^{-2}·s^{-1}
(DLI 11.8 mol·m^{-2}·d $^{-1}$)

800 µmol·m^{-2}·s^{-1}
(DLI 46.8 mol·m^{-2}·d $^{-1}$)

(Del Moro and Walters, Unpublished)

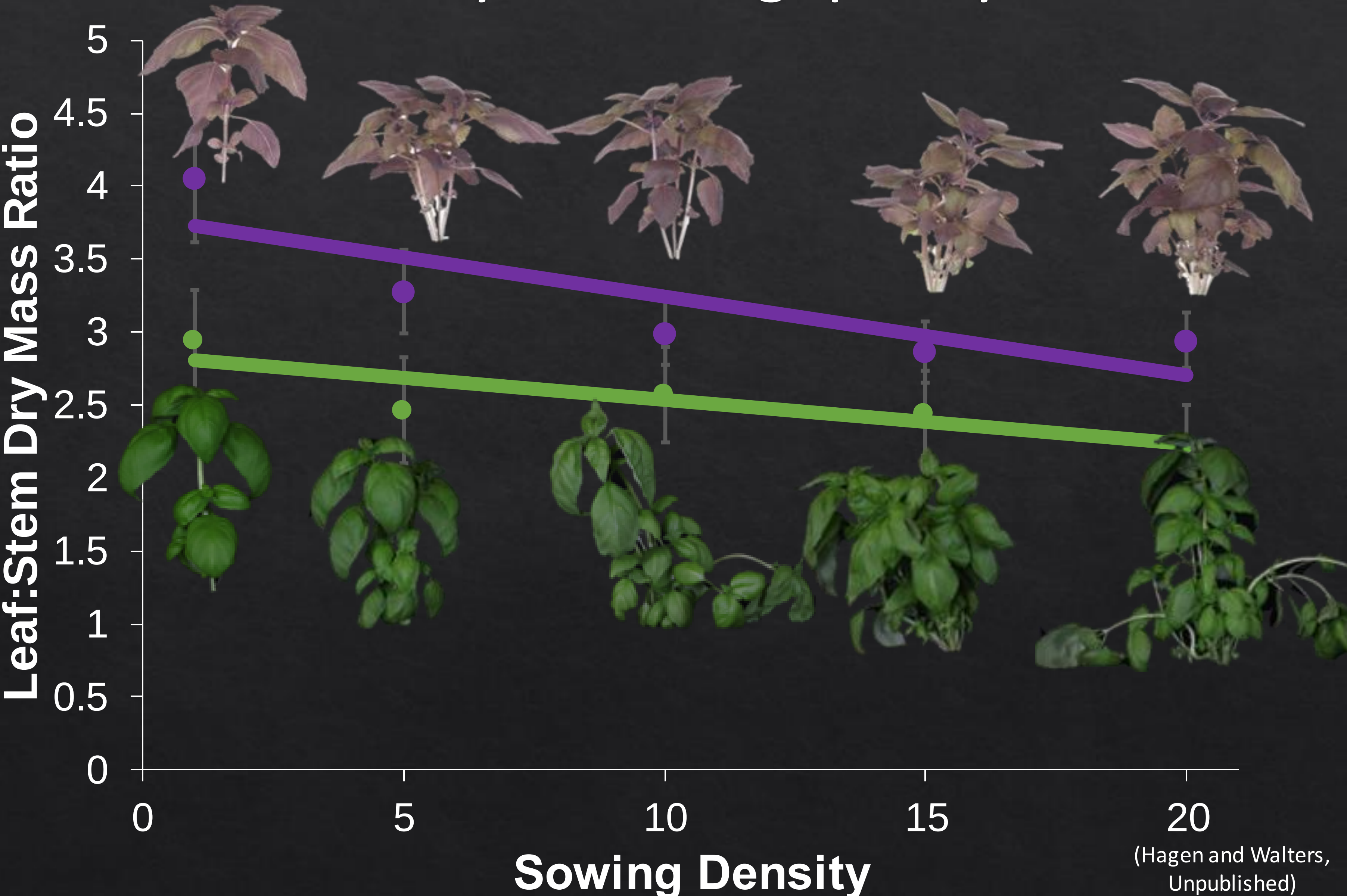
Should we sow one seed per cell?

Cell fresh mass increases with increased sowing density.



(Hagen and Walters, Unpublished)

Leaf:Stem dry mass ratio decreases with increase density, reducing quality



(Hagen and Walters, Unpublished)

Basil planting density: Balancing yield and crop quality

(Hagen and Walters, Unpublished)

Nutrient Solution Concentration

(Walters and Currey, 2018)

Fresh mass (g) of *Ocimum basilicum* ‘Nufar’

Electrical conductivity (dS·m^{-1})

0.5	1.0	2.0	3.0	4.0

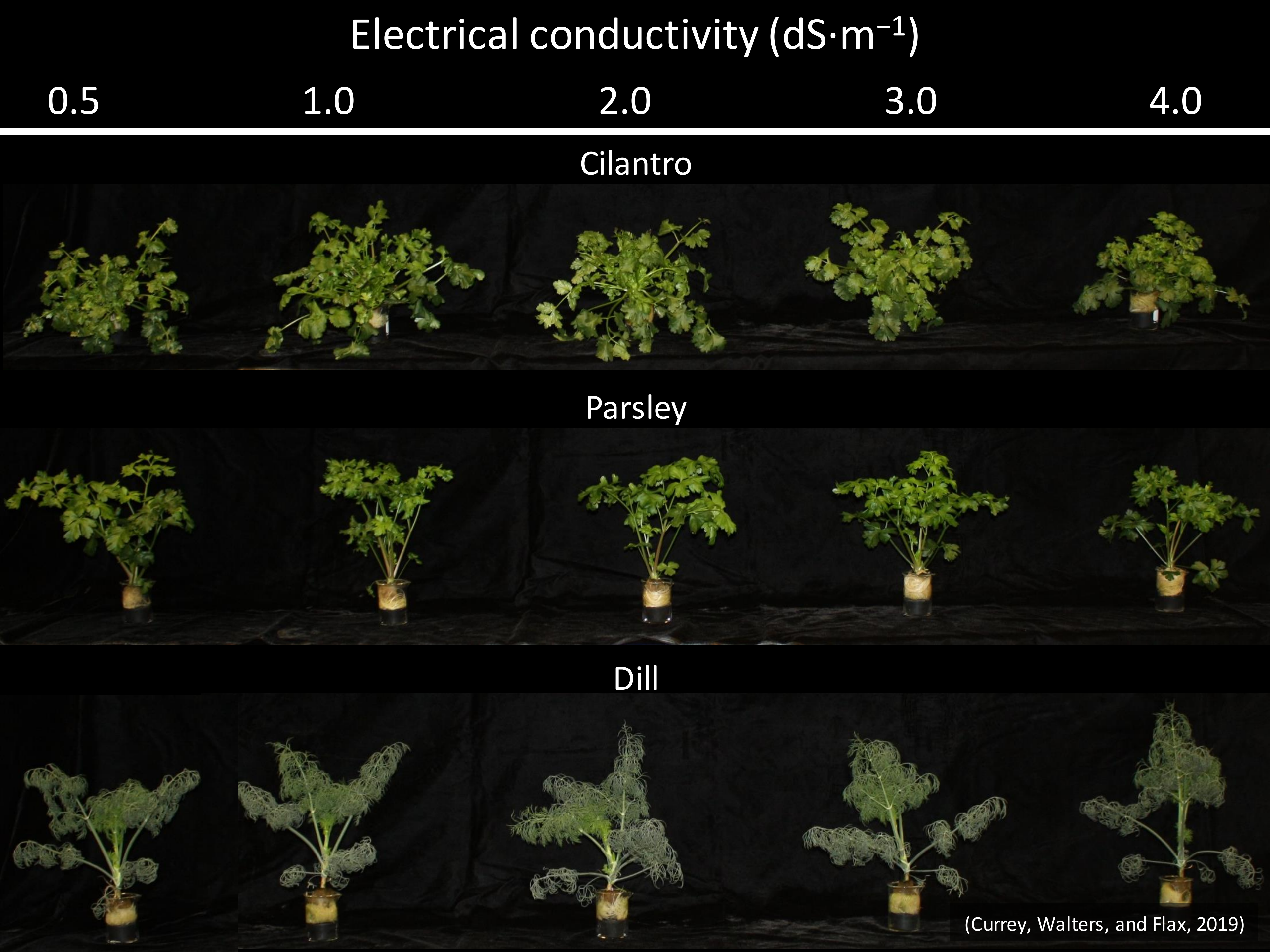
Low DLI

12.6

High DLI

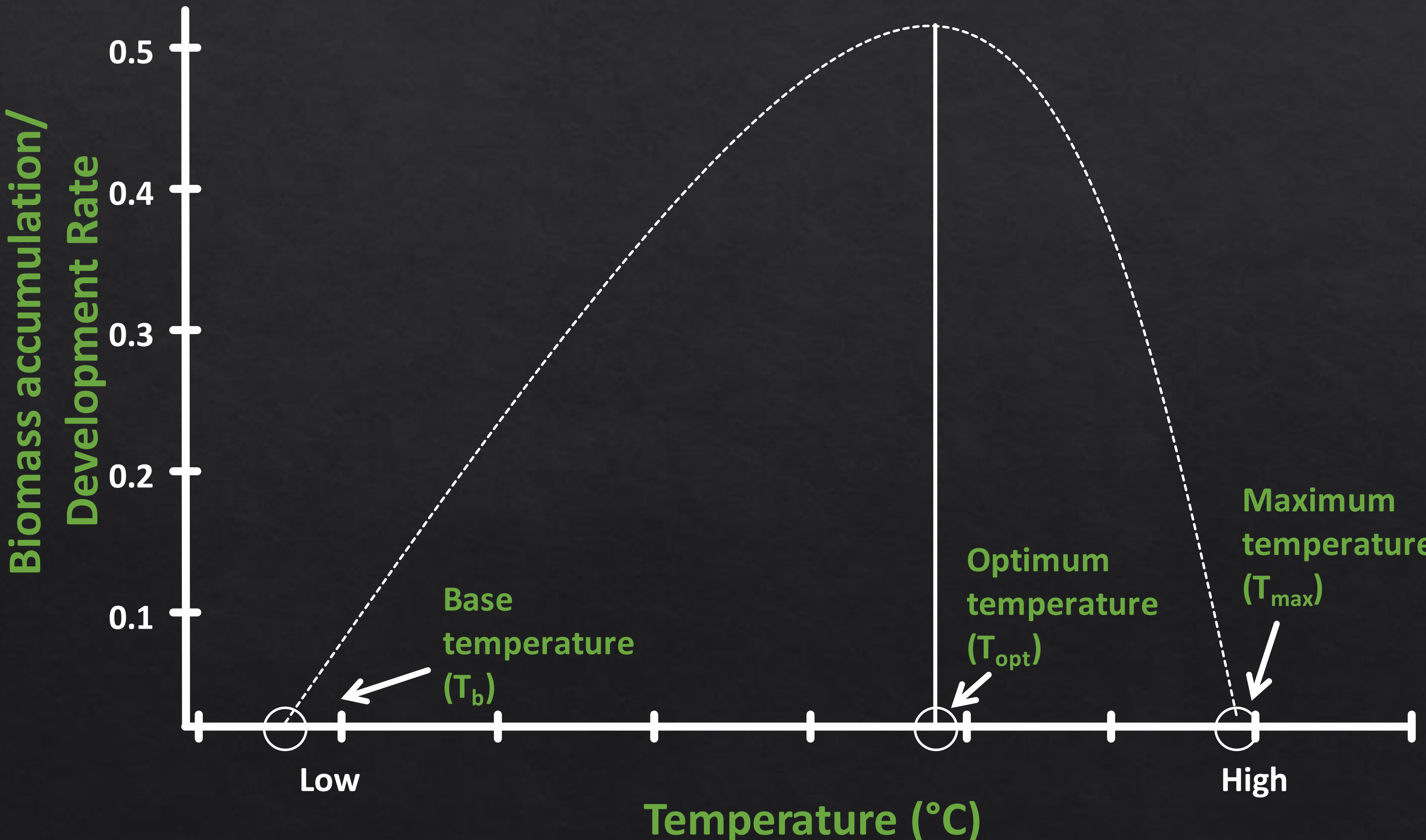
30.5

(Walters and Currey, 2018)



Electrical conductivity (dS·m⁻¹)
0.5
1.0
2.0
3.0
4.0
Cilantro
Parsley
Dill
(Currey, Walters, and Flax, 2019)

Temperature Response Curve



Sweet basil ‘Nufar’

Temperature (°F)

52 63 73 84 95

(Walters and Currey, 2019)

Lemon basil 'Lime'

Temperature (°F)

52 63 73 84 95

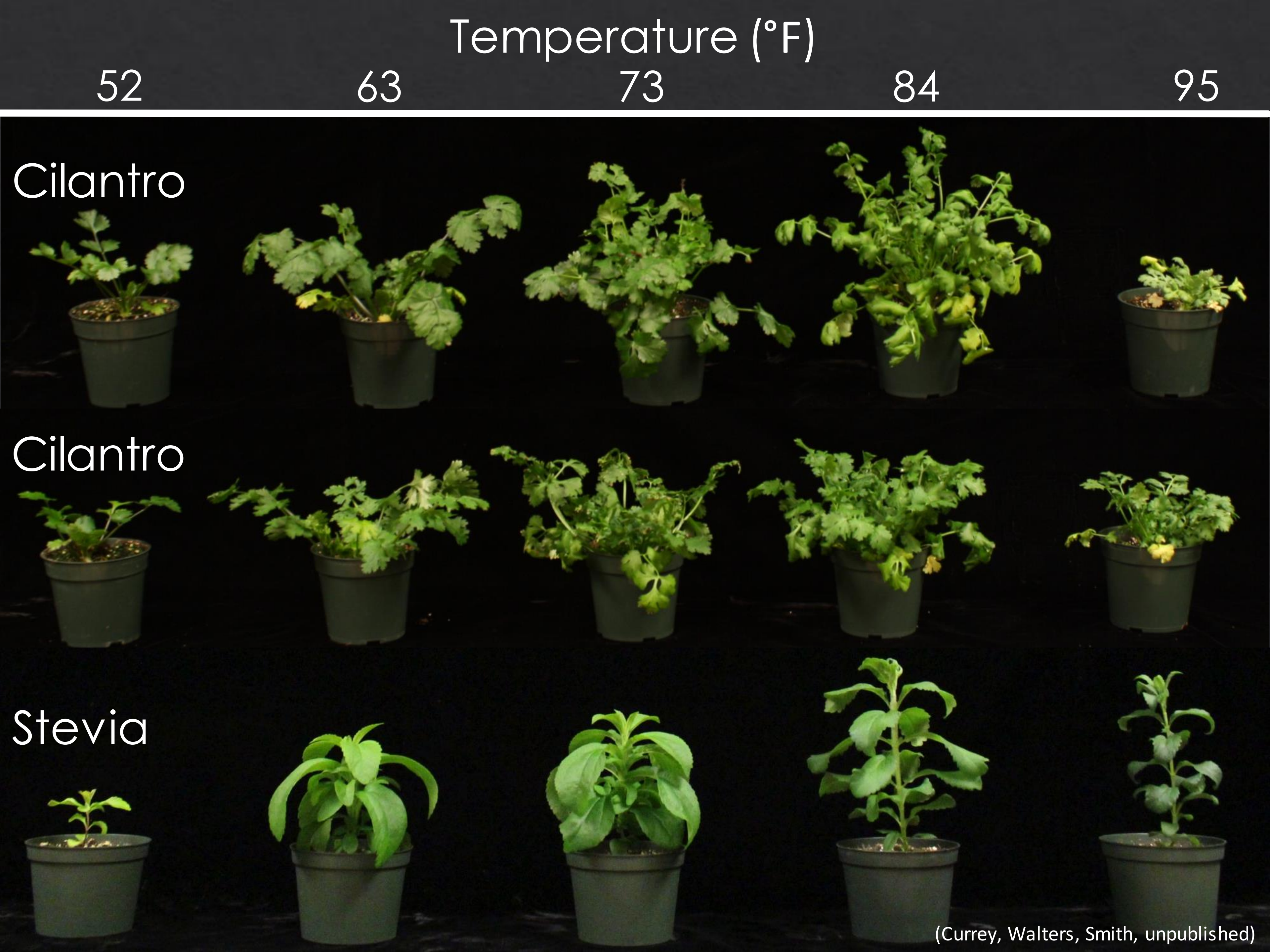
(Walters and Currey, 2019)

Holy basil

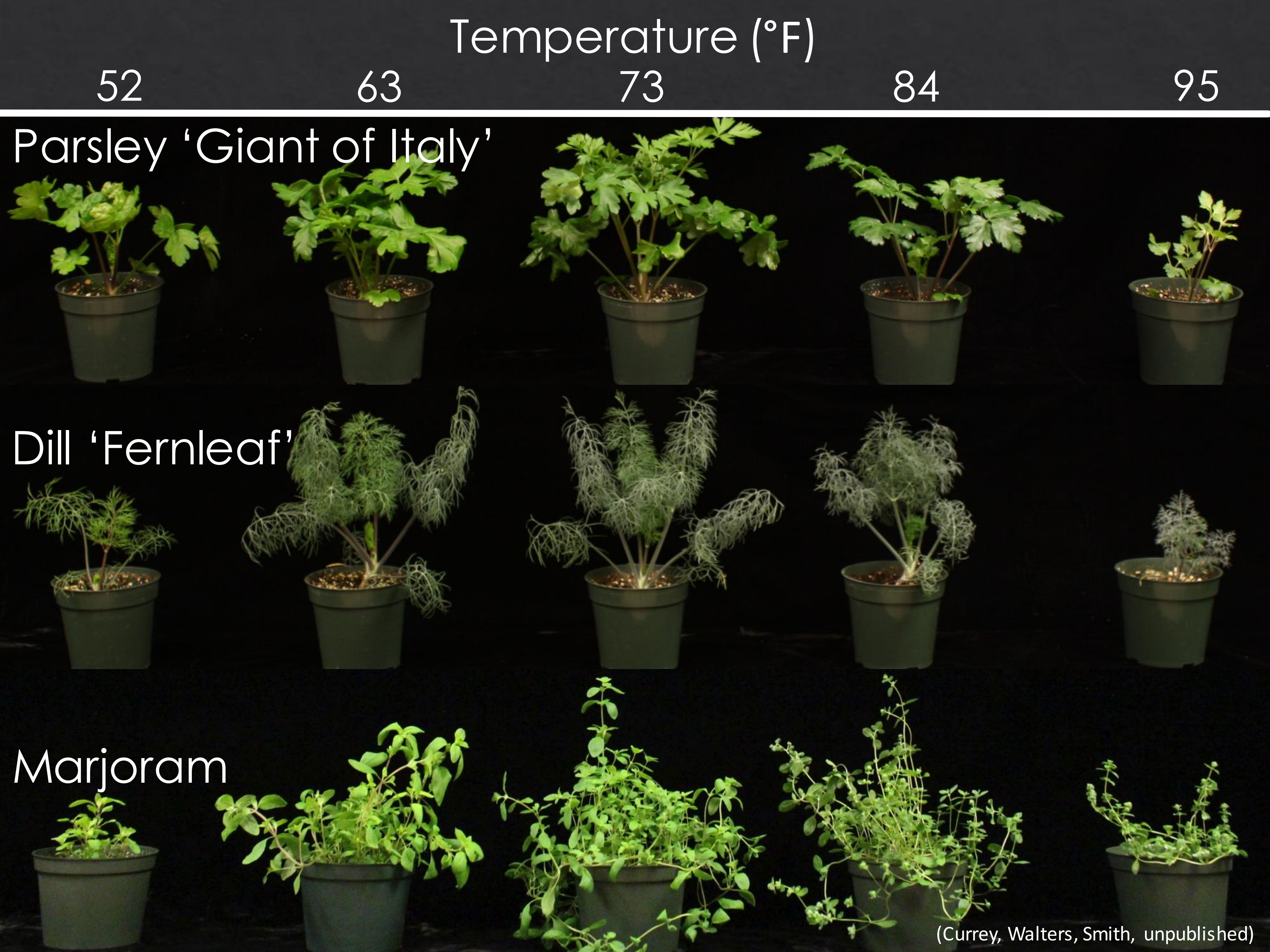
Temperature (°F)

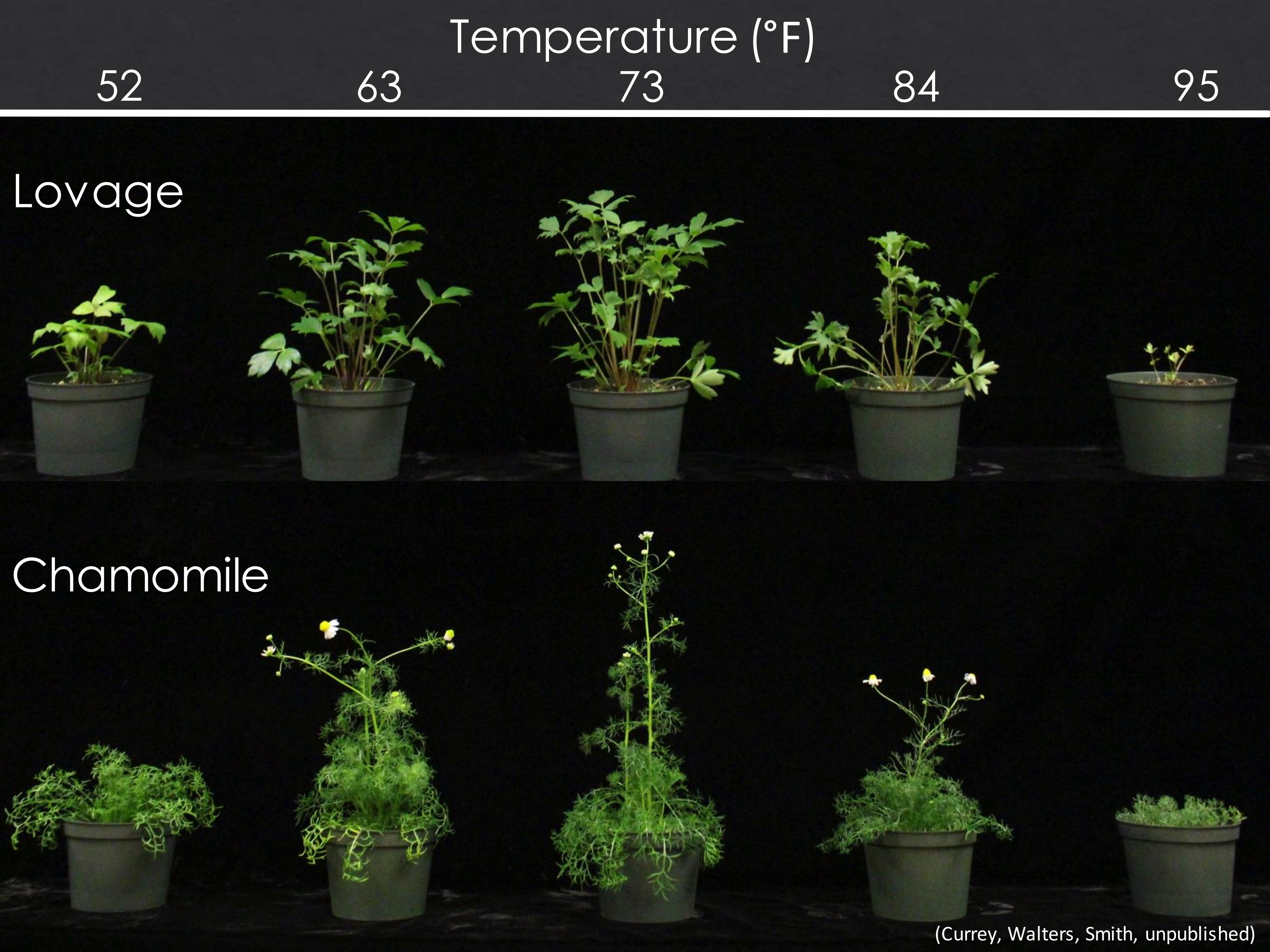
52 63 73 84 95

(Walters and Currey, 2019)

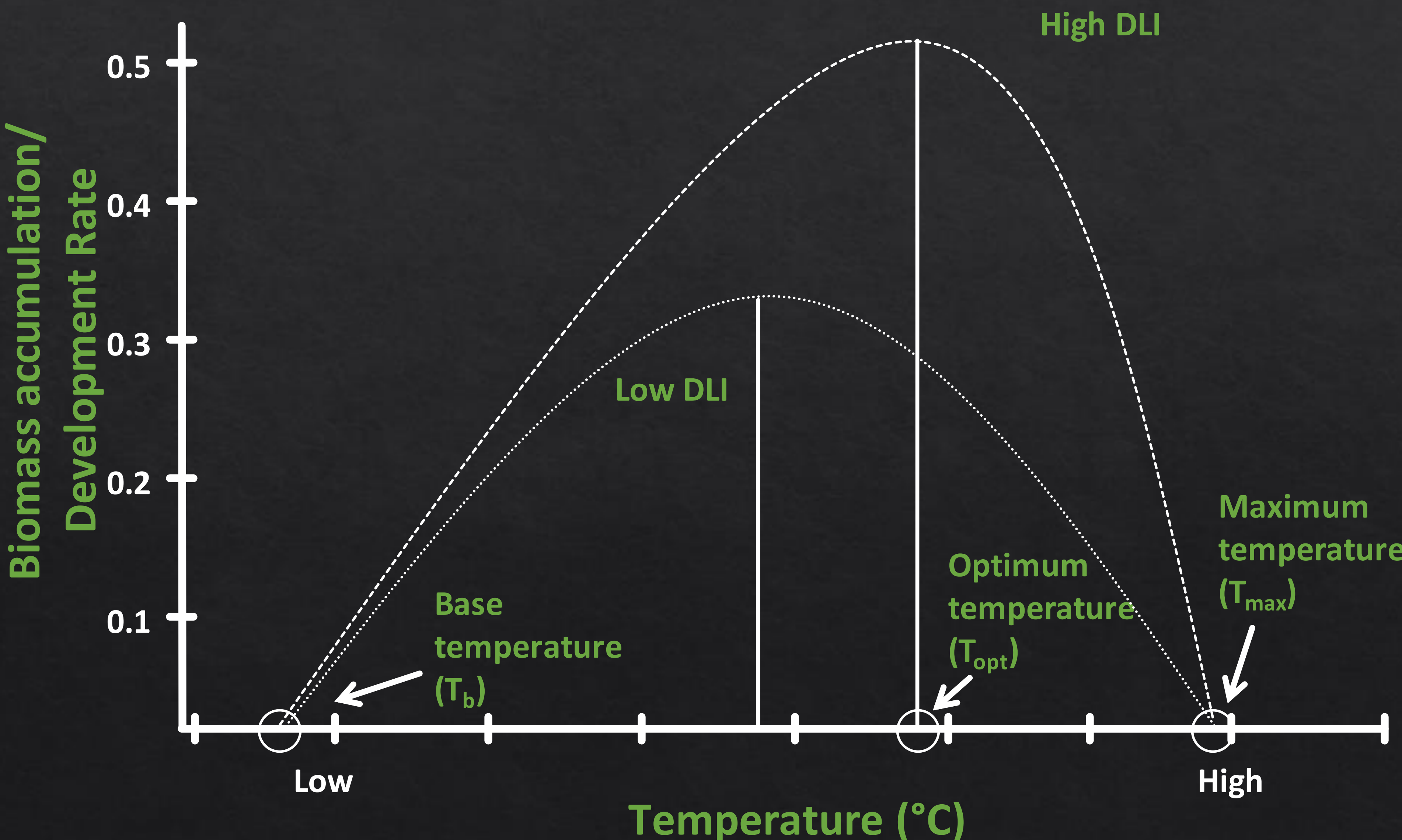


Temperature (°F)
52
63
73
84
95
Cilantro
Cilantro
Stevia
(Currey, Walters, Smith, unpublished)

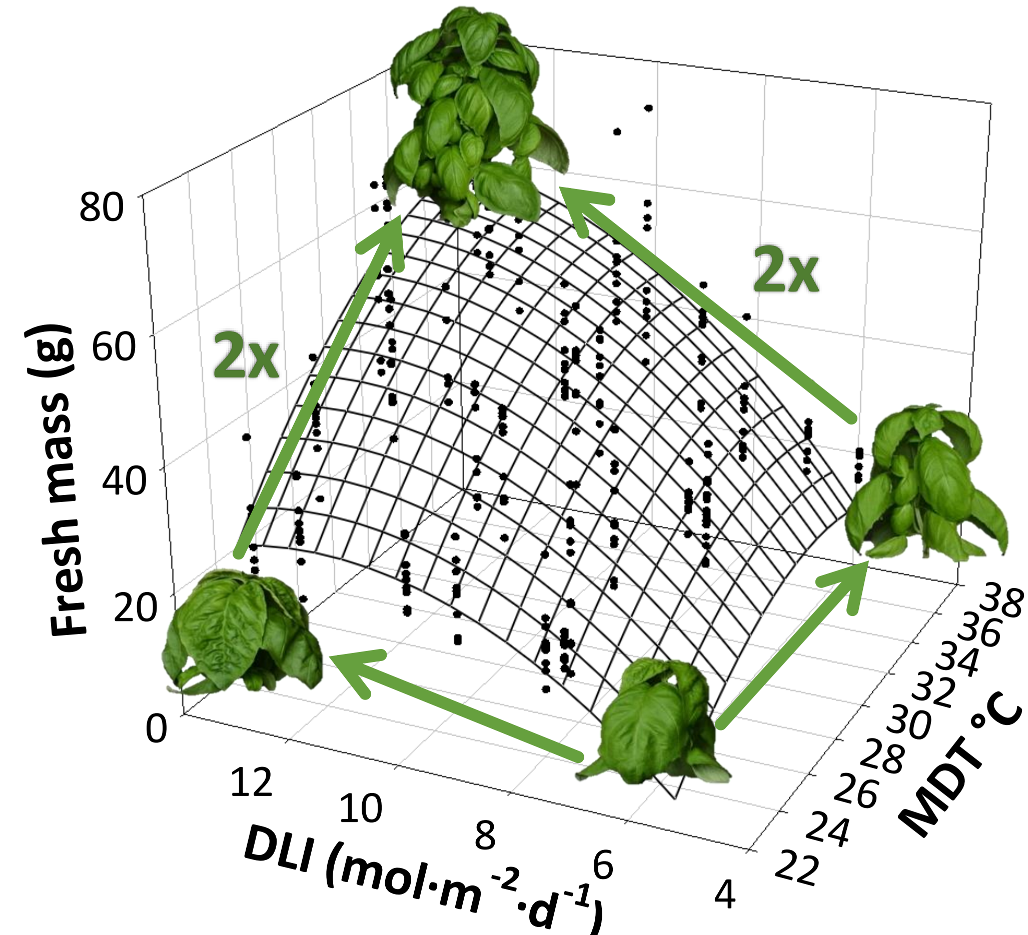

Temperature (°F)
52
63
73
84
95
Parsley 'Giant of Italy'
Dill 'Fernleaf'
Marjoram
(Currey, Walters, Smith, unpublished)


Temperature (°F)
52
63
73
84
95
Lovage
Chamomile
(Currey, Walters, Smith, unpublished)

Temperature Response Curve



Sweet Basil ‘Nufar’ Fresh Mass (g)

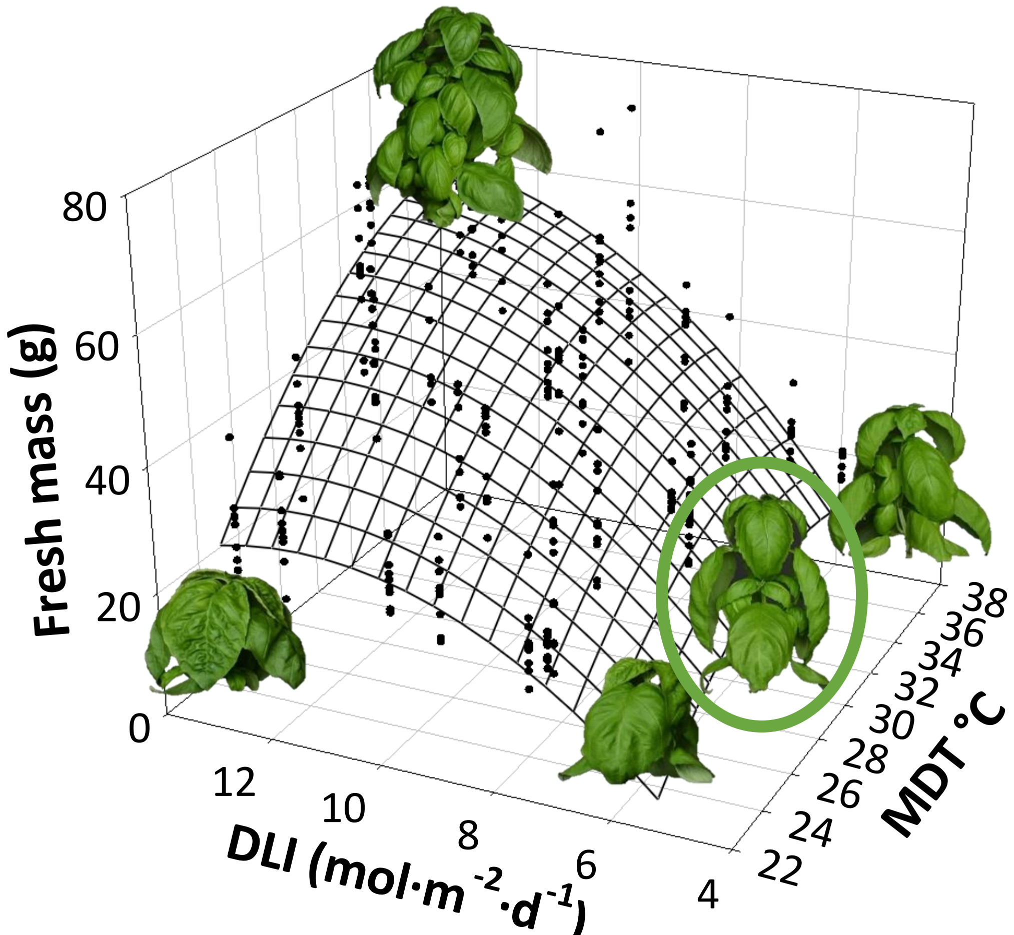


$f = -223.14 + 11.46*MDT + 11.08*DLI - 0.196*MDT^2 - 0.692*DLI^2 + 0.222*MDT*DLI$

$R^2 = 0.632$

(Walters and Lopez, 2022)

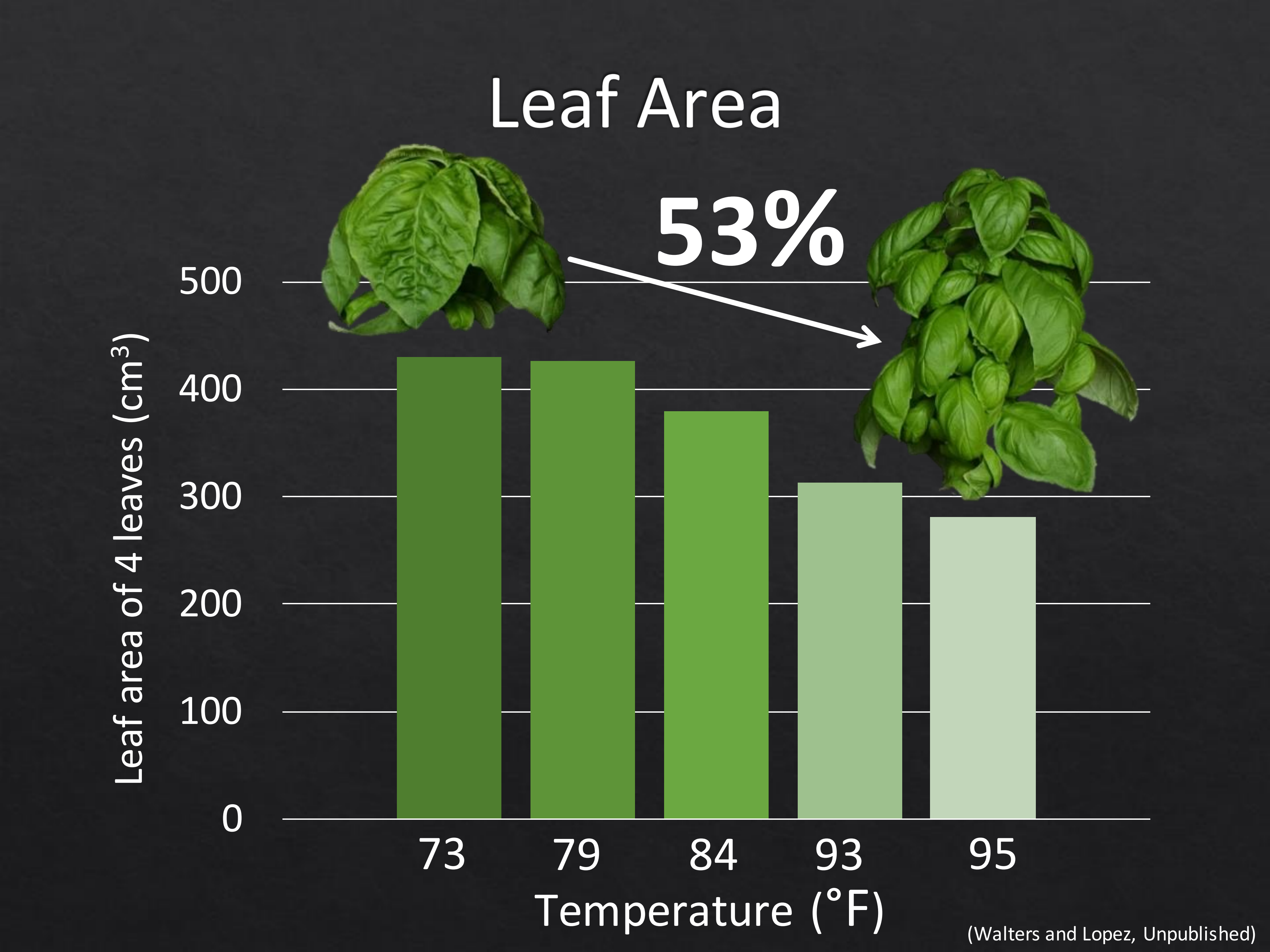
Sweet Basil 'Nufar' Fresh Mass (g)



$f = -223.14 + 11.46*MDT + 11.08*DLI - 0.196*MDT^2 - 0.692*DLI^2 + 0.222*MDT*DLI$

$R^2 = 0.632$

(Walters and Lopez, 2022)


Leaf Area
53%
Leaf area of 4 leaves (cm^3)
500
400
300
200
100
0
73
79
84
93
95
Temperature (°F)
(Walters and Lopez, Unpublished)

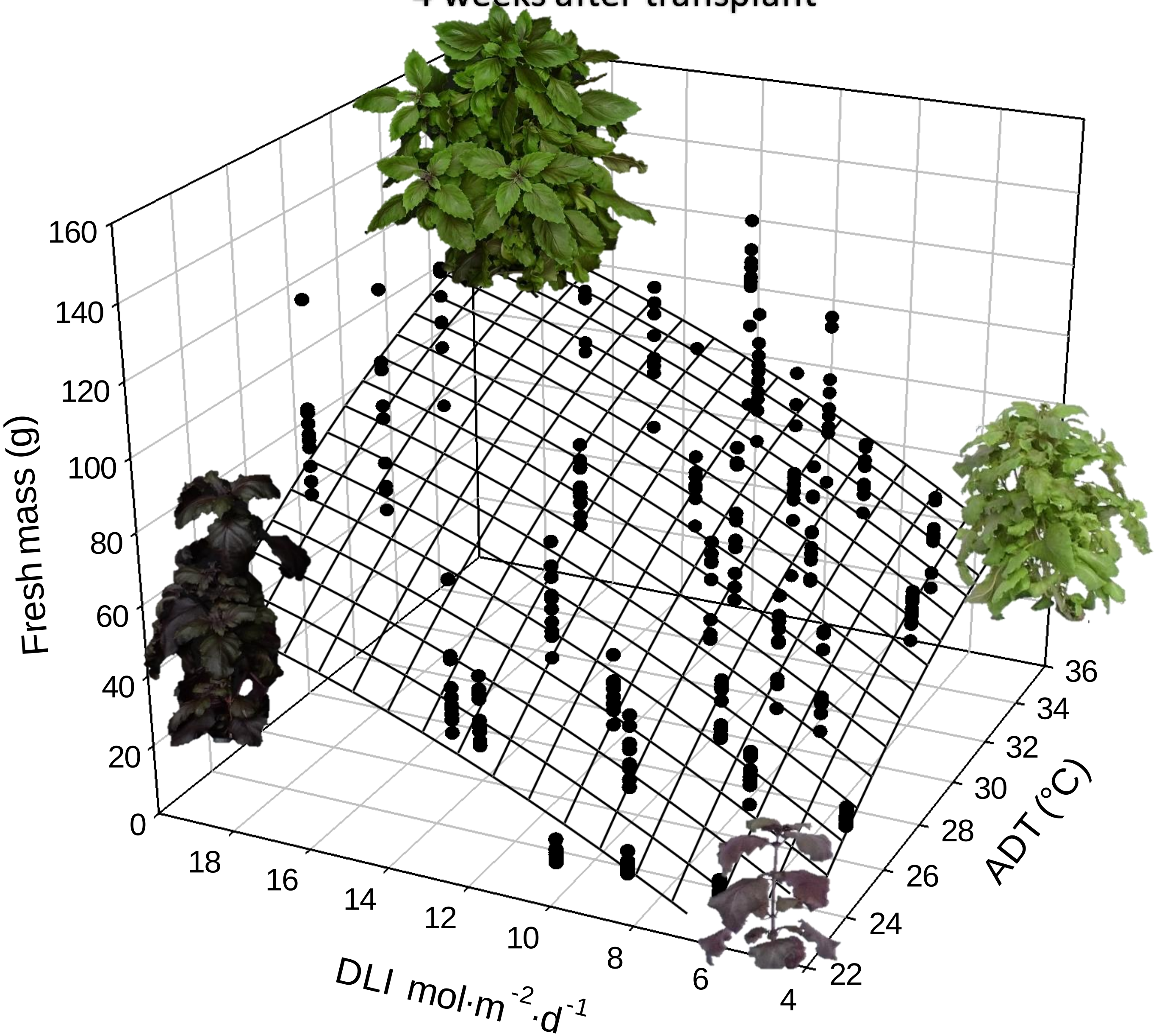
Purple Basil ‘Dark Opal’

4 weeks after transplant

(Walters and Lopez, Unpublished)

Purple Basil ‘Dark Opal’

4 weeks after transplant



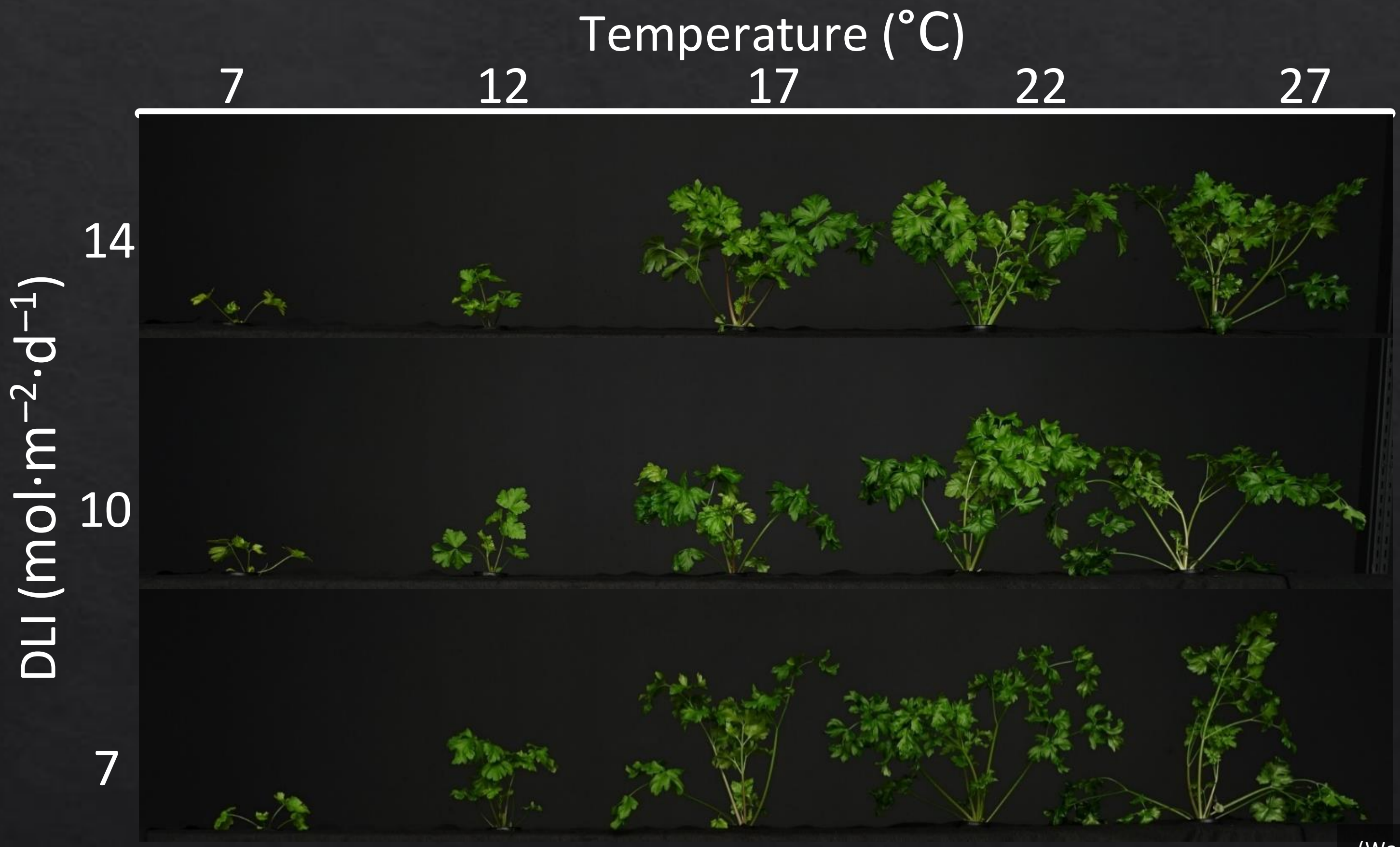
R^2 = 0.79

(Walters and Lopez, Unpublished)

$f = -10.13 + 0.149*MDT + 0.0446*DLI - 0.0745*DLI^2 + 0.0701*MDT*DLI$ NOTE: not the equation for this graph

Parsley ‘Giant of Italy’

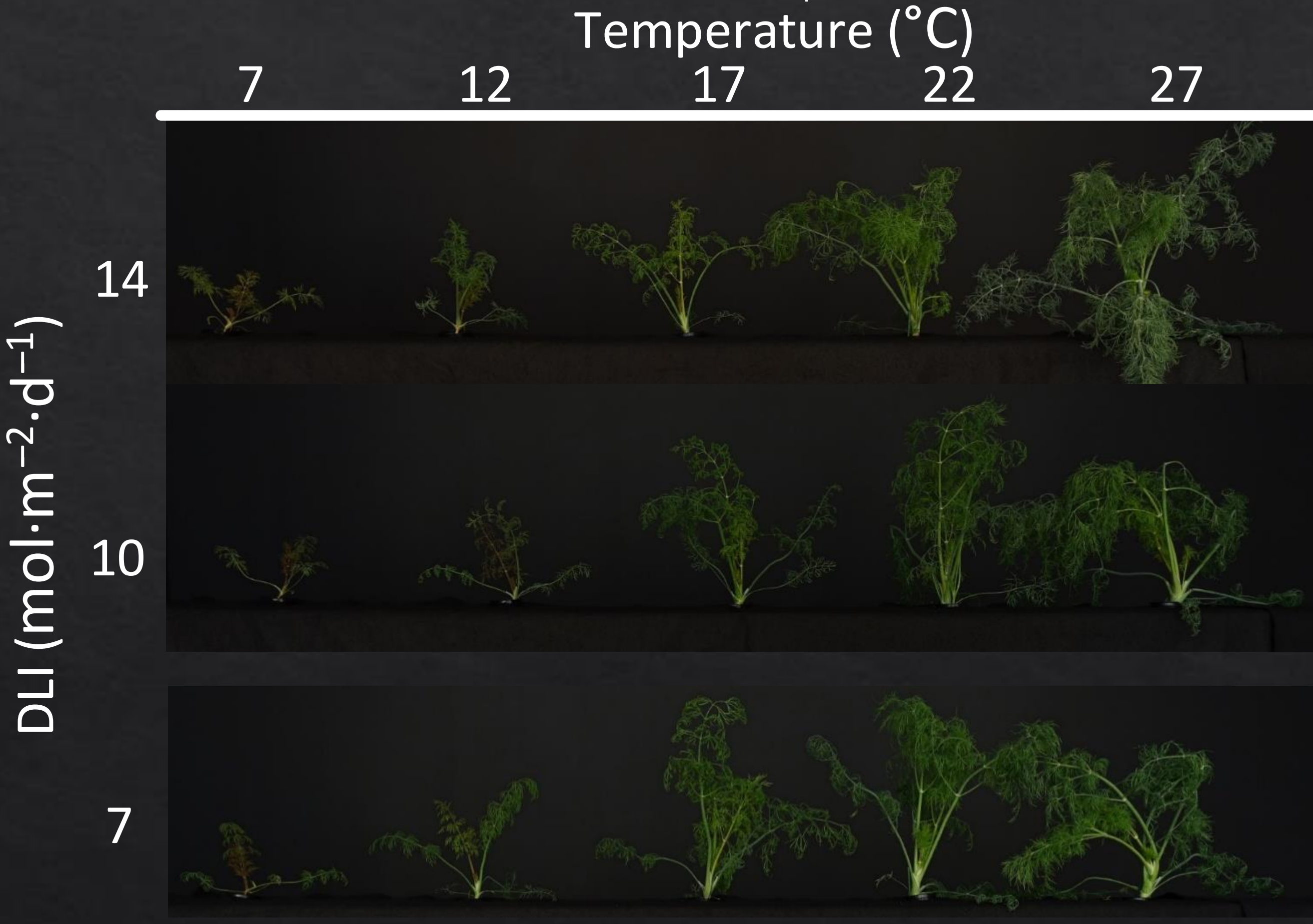
4 weeks after transplant



(Walters and Lopez, 2021)

Dill ‘Bouquet’

3 weeks after transplant



(Walters and Lopez, 2021)

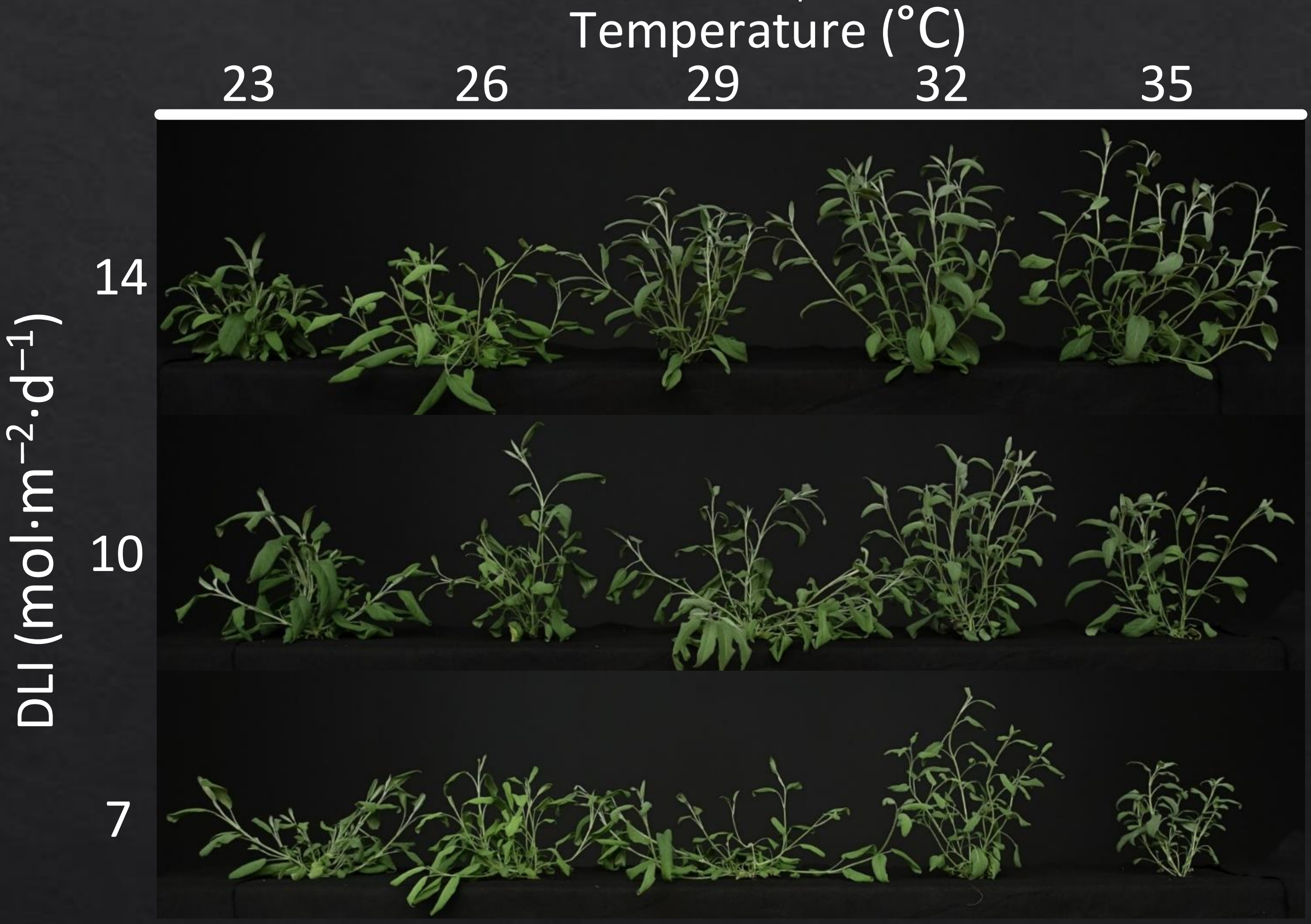
Watercress

2 weeks after transplant

(Walters and Lopez, 2021)

Sage 'Extrakta'

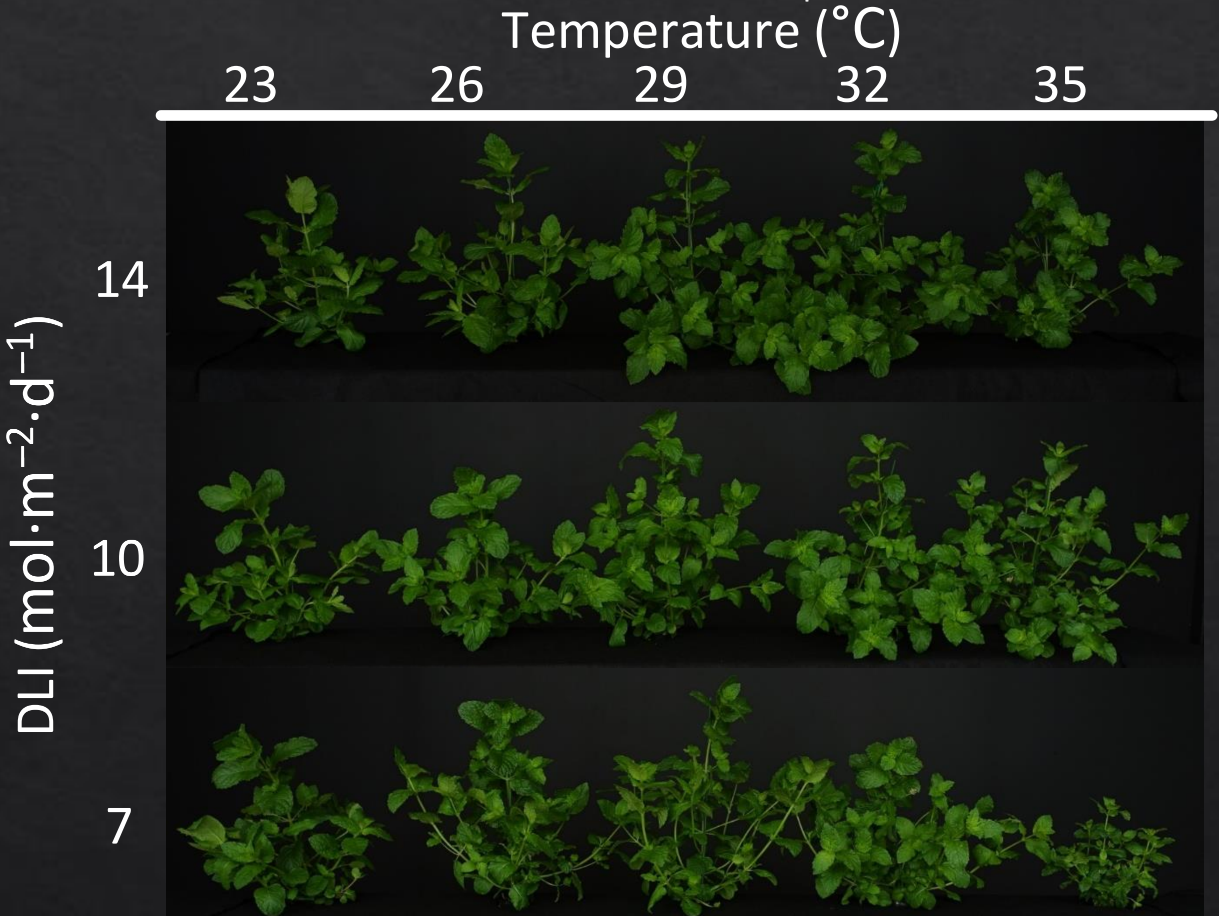
5 weeks after transplant



(Walters and Lopez, Unpublished)

Spearmint ‘Spanish’

3 weeks after transplant



(Walters and Lopez, Unpublished)

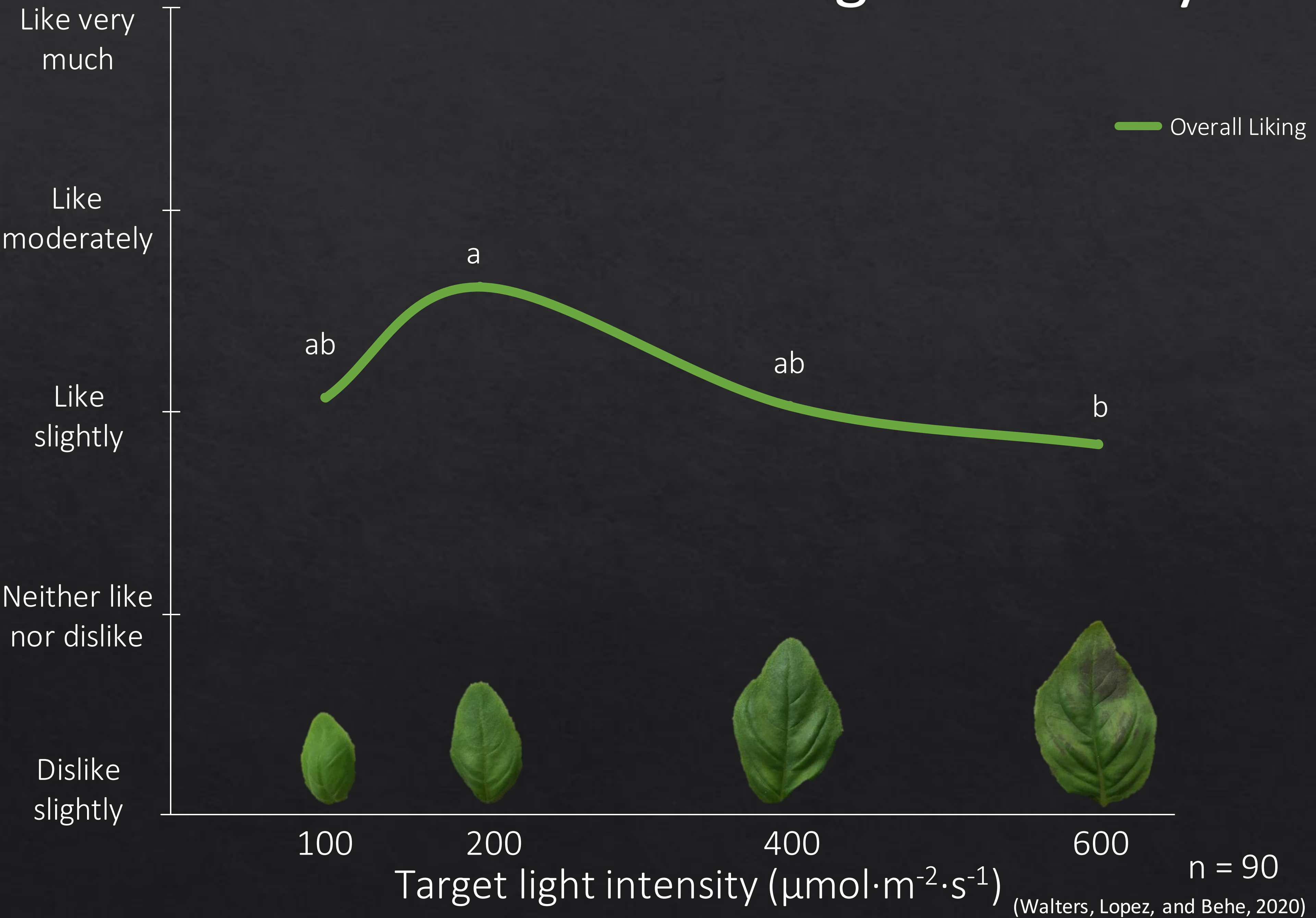
What about flavor?

Compound concentrations change with changing environmental conditions

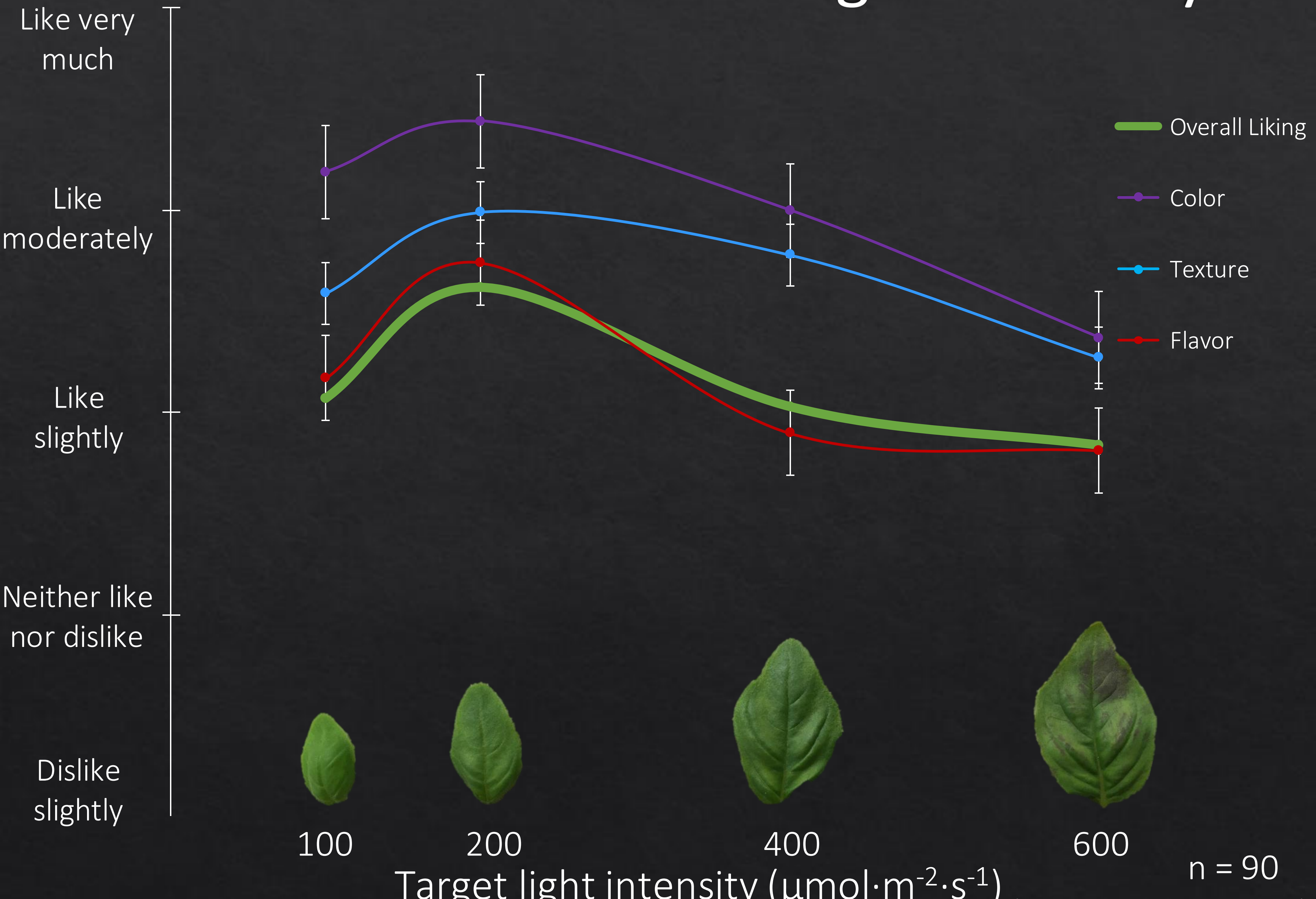



SENSORY 1
SENSORY 2
SENSORY 3
SENSORY 4
SENSORY 5

Consumer Preference: Light Intensity

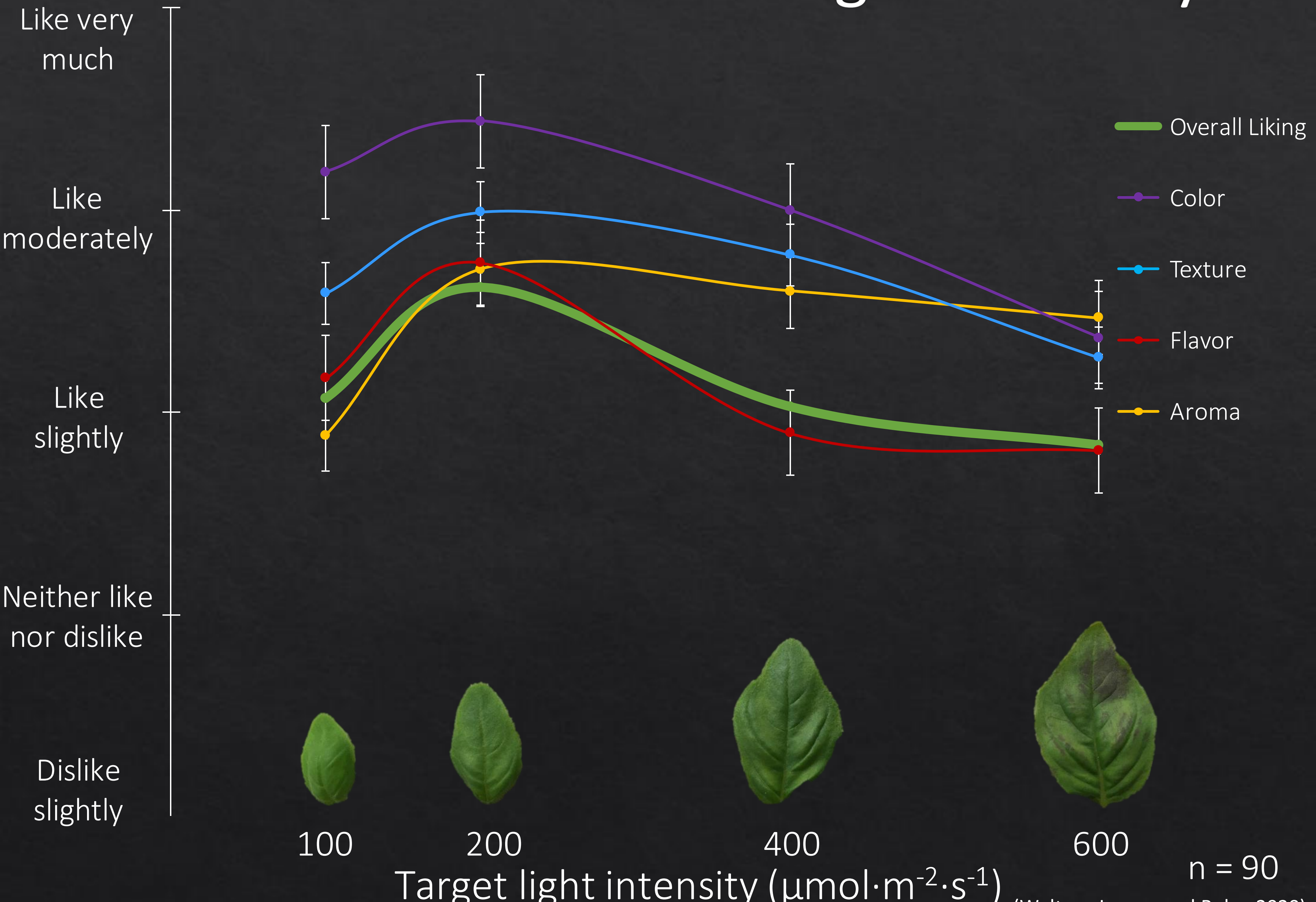


Consumer Preference: Light Intensity



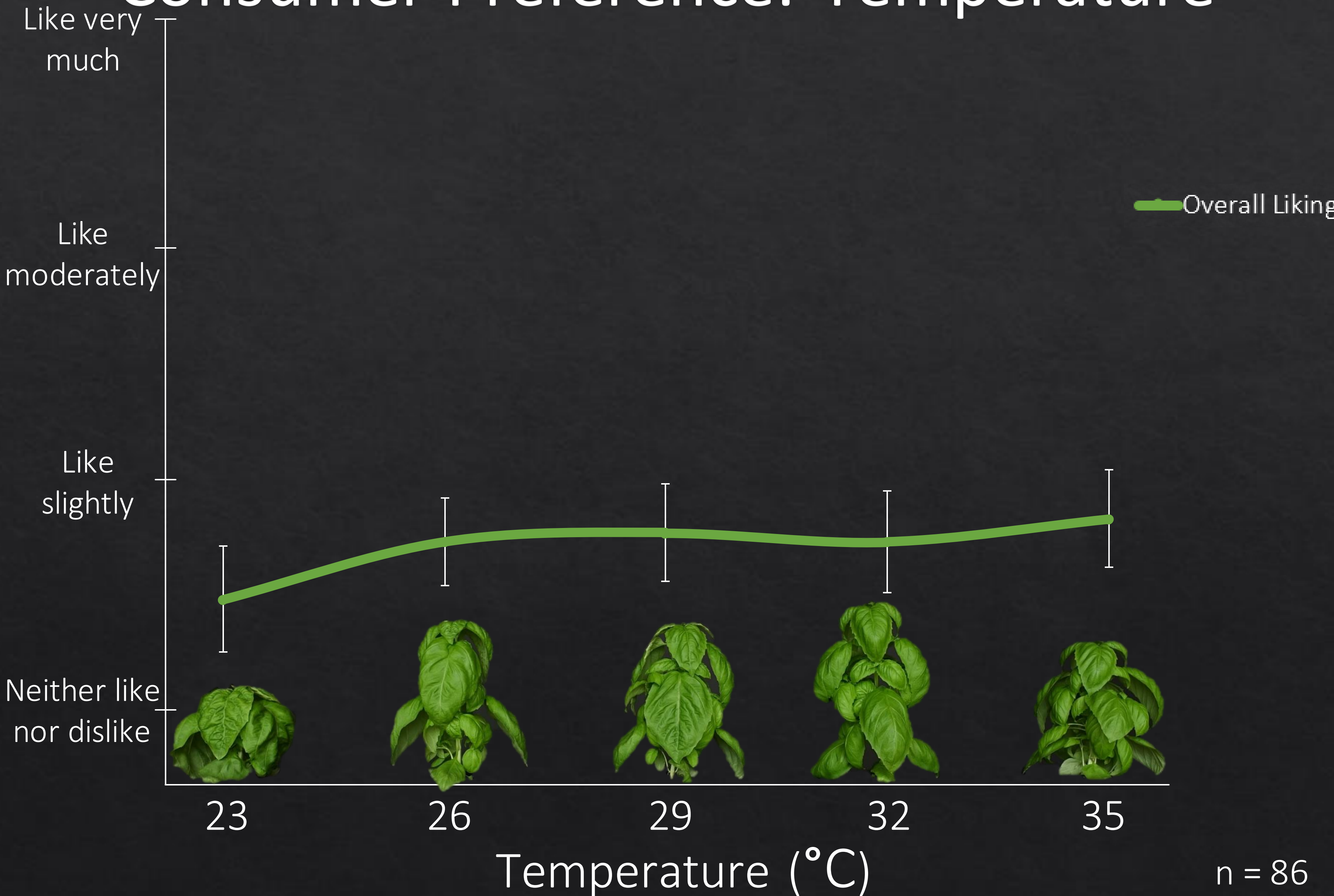
(Walters, Lopez, and Behe, 2020)

Consumer Preference: Light Intensity



(Walters, Lopez, and Behe, 2020)

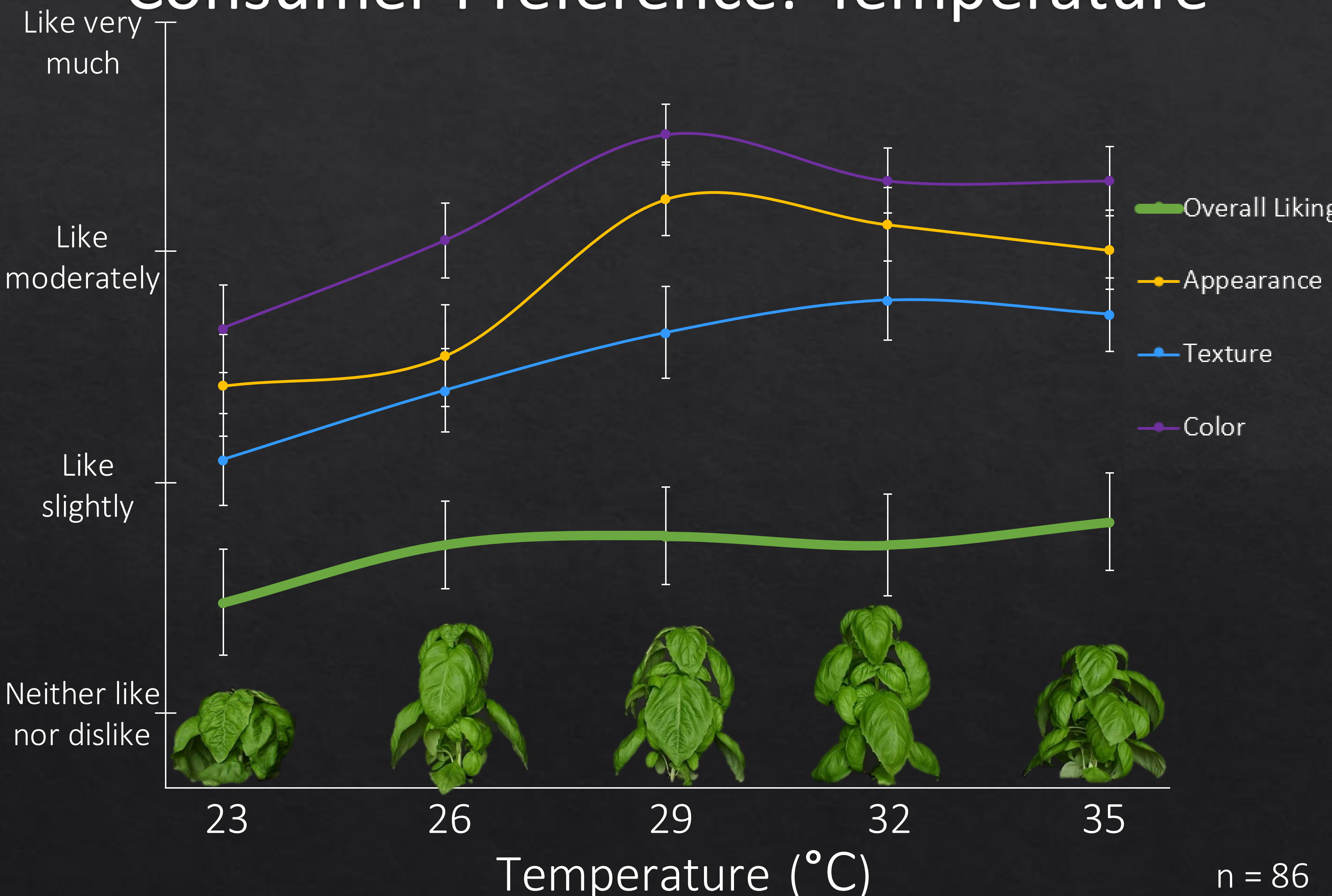
Consumer Preference: Temperature



n = 86

(Walters and Lopez, 2022)

Consumer Preference: Temperature



n = 86

(Walters and Lopez, 2022)

Summary

- Keep production goals in mind
- Be conscious of cultivar differences
- Optimize the growing environment to increase yield
- Environmental changes alter color and flavor

CEA HERB:

Controlled Environment Agriculture Herb Extension and Research Base

1. Marketing and Economics
   - Increase the demand and marketability of culinary herbs through marketplace feasibility studies of different production, sensory, and marketing characteristics.
2. Production, Post-harvest, Food Safety, and Plant Protection
   - Increase and optimize herb growth, yield, disease management, and post-harvest quality through CE environmental and cultural control and develop CE curricula related to food safety.
3. Engage Stakeholders
   - Develop new profitable and sustainable CE herb grower resources, protocols, and tools that lead to high-quality, safe-to-eat, flavorful, and nutritious herbs with an extended shelf-life.

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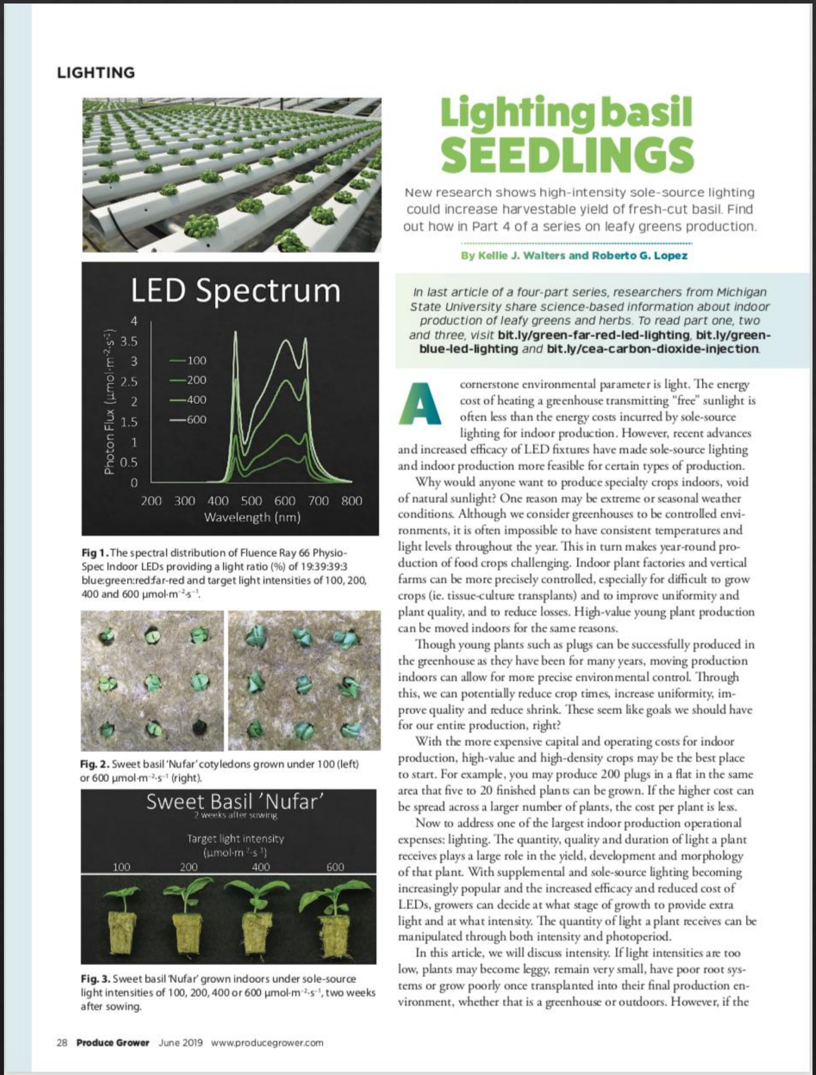


Lighting basil SEEDLINGS

New research shows high-intensity sole-source lighting could increase harvestable yield of fresh-cut basil. Find out how in Part 4 of a series on leafy greens production.

By Kellie J. Walters and Roberto G. Lopez

In last article of a four-part series, researchers from Michigan State University share science-based information about indoor production of leafy greens and herbs. To read part one, two and three, visit **bit.ly/green-far-red-led-lighting**, **bit.ly/green-blue-led-lighting** *and* **bit.ly/cea-carbon-dioxide-injection**.

A cornerstone environmental parameter is light. The energy cost of heating a greenhouse transmitting "free" sunlight is often less than the energy costs incurred by sole-source lighting for indoor production. However, recent advances and increased efficacy of LED fixtures have made sole-source lighting and indoor production more feasible for certain types of production.

Why would anyone want to produce specialty crops indoors, void of natural sunlight? One reason may be extreme or seasonal weather conditions. Although we consider greenhouses to be controlled environments, it is often impossible to have consistent temperatures and light levels throughout the year. This in turn makes year-round production of food crops challenging. Indoor plant factories and vertical farms can be more precisely controlled, especially for difficult to grow crops (ie. tissue-culture transplants) and to improve uniformity and plant quality, and to reduce losses. High-value young plant production can be moved indoors for the same reasons.

Though young plants such as plugs can be successfully produced in the greenhouse as they have been for many years, moving production indoors can allow for more precise environmental control. Through this, we can potentially reduce crop times, increase uniformity, improve quality and reduce shrink. These seem like goals we should have for our entire production, right?

With the more expensive capital and operating costs for indoor production, high-value and high-density crops may be the best place to start. For example, you may produce 200 plugs in a flat in the same area that five to 20 finished plants can be grown. If the higher cost can be spread across a larger number of plants, the cost per plant is less.

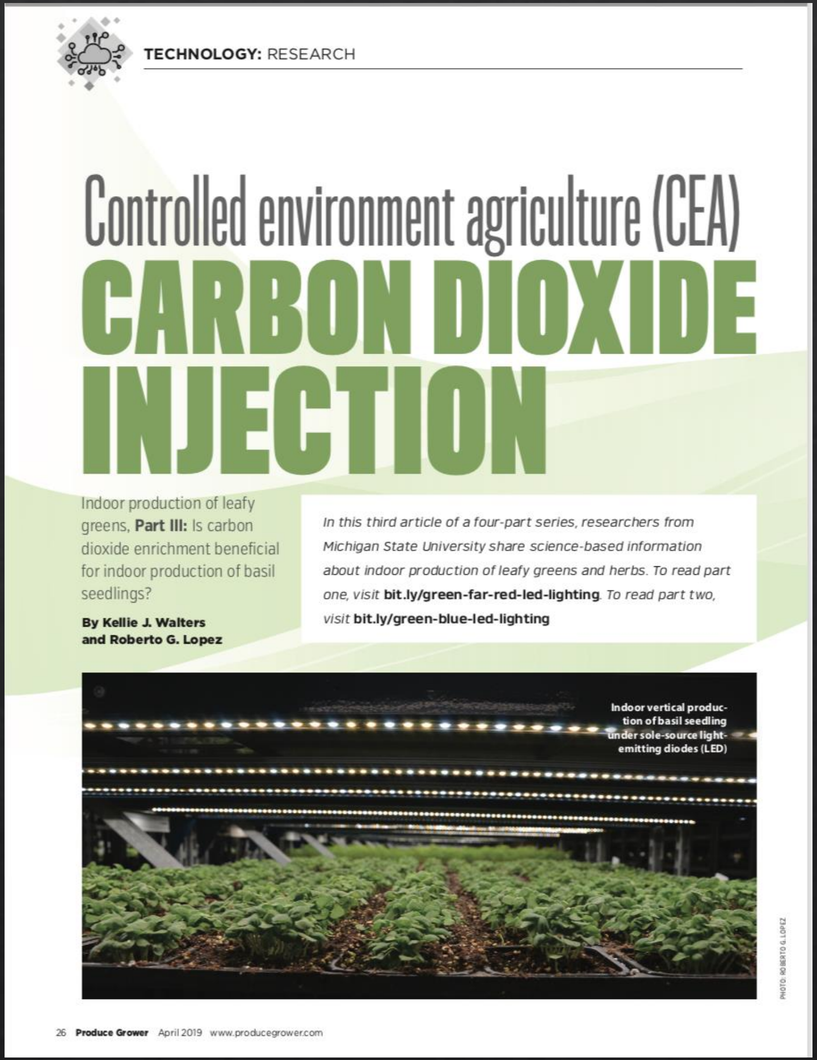
Now to address one of the largest indoor production operational expenses: lighting. The quantity, quality and duration of light a plant receives plays a large role in the yield, development and morphology of that plant. With supplemental and sole-source lighting becoming increasingly popular and the increased efficacy and reduced cost of LEDs, growers can decide at what stage of growth to provide extra light and at what intensity. The quantity of light a plant receives can be manipulated through both intensity and photoperiod.

In this article, we will discuss intensity. If light intensities are too low, plants may become leggy, remain very small, have poor root systems or grow poorly once transplanted into their final production environment, whether that is a greenhouse or outdoors. However, if the

Fig 1. The spectral distribution of Fluence Ray 66 Physio-Spec Indoor LEDs providing a light ratio (%) of 19:39:39:3 blue:green:red:far-red and target light intensities of 100, 200, 400 and 600 $\mu mol \cdot m^{-2} \cdot s^{-1}$.

Fig. 2. Sweet basil 'Nufar' cotyledons grown under 100 (left) or 600 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (right).

Fig. 3. Sweet basil 'Nufar' grown indoors under sole-source light intensities of 100, 200, 400 or 600 $\mu mol \cdot m^{-2} \cdot s^{-1}$, two weeks after sowing.



Controlled environment agriculture (CEA) CARBON DIOXIDE INJECTION

Indoor production of leafy greens, **Part III:** Is carbon dioxide enrichment beneficial for indoor production of basil seedlings?

By Kellie J. Walters and Roberto G. Lopez

In this third article of a four-part series, researchers from Michigan State University share science-based information about indoor production of leafy greens and herbs. To read part one, visit **bit.ly/green-far-red-led-lighting**. *To read part two, visit* **bit.ly/green-blue-led-lighting**

Indoor vertical production of basil seedling under sole-source light-emitting diodes (LED)

PHOTO: ROBERTO G. LOPEZ