



Microgreens - A New Specialty Crop

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What are Microgreens?

- Young vegetable, herb or other edible plants.
- Range in size from 1 to 1½" long
- Includes a single central stem cut just above the soil line during harvesting.
- It has two fully developed cotyledon leaves
- One pair very small, partially developed true leaves.
- The typical stem and leaf configuration for micro greens is about 1" to 1½" in height, and ½" to 1" in width across the top.



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Types of Microgreens

- Primary species grown:
 - Arugula
 - Beets
 - Kale
 - Basil
 - Cilantro
 - A medley called Rainbow Mix
- Now: well over 40 different species



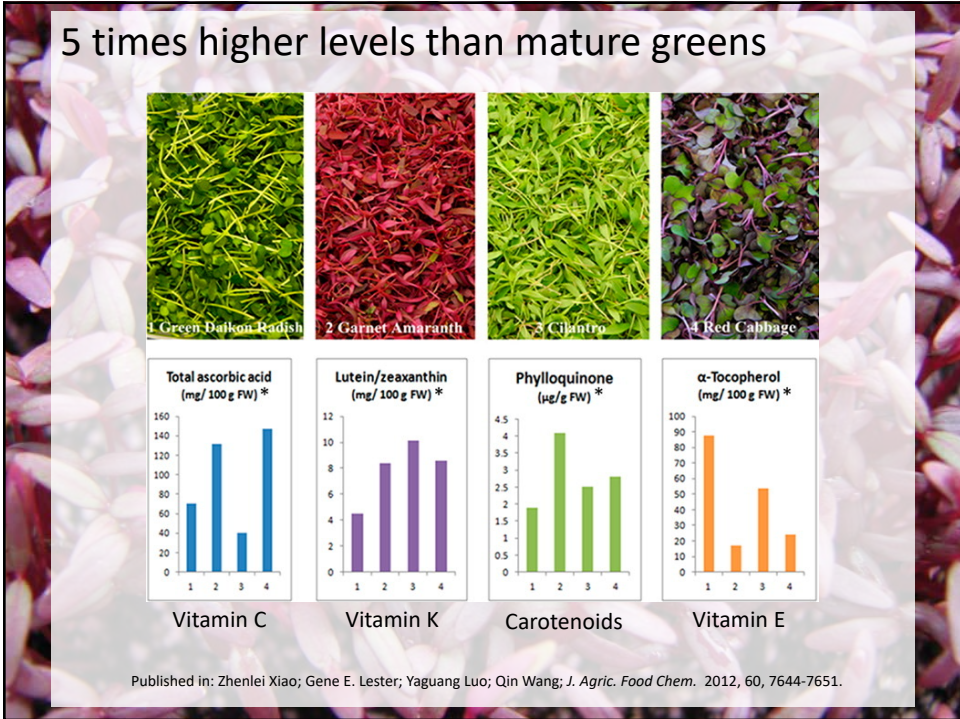
How are Microgreens Used?

- They provide intense flavors, vivid colors, and crisp textures.
- They are used as a visual enhancement and flavor accent.
- Nowadays also being used as a salad ingredient rather than as a garnish.

Microgreens

- Recently, microgreens have gained popularity as a new culinary trend.
- Quick turnaround time 12-18 days from sowing to harvest.
- When compared with nutritional concentrations in mature leaves, microgreens contain higher nutritional densities.

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What is the true value to consumers?

Table 1 – Contents of ascorbic acid (vitamin C), α-tocopherol (vitamin E) and phyloquinone (vitamin K) in some species of microgreens and relative amount of fresh product (FP) necessary to satisfy the recommended daily intake of each vitamin for an adult^{1,2}.

Microgreen	Species	Vitamin content			Amount of FP necessary to satisfy the recommended daily intake of:		
		Vit. C	Vit. E	Vit. K	Vit. C	Vit. E	Vit. K
		mg/100 g FP	mg/100 g FP	µg/g FP	g	g	g
Garnet amaranth	<i>Amaranthus hypochondriacus</i> L.	131.6	17.1	4.1	46	76	17
Opal basil	<i>Ocimum basilicum</i> L.	90.8	24.0	3.2	66	54	22
Red beet	<i>Beta vulgaris</i> L.	46.4	34.5	2.0	129	38	35
Red cabbage	<i>Brassica oleracea</i> L. var. <i>capitata</i>	147.0	24.1	2.8	41	54	25
Cilantro	<i>Coriandrum sativum</i> L.	40.6	53.0	2.5	148	25	28
Peppercress	<i>Lepidium banariense</i> L.	57.2	41.2	2.4	105	32	29
Pea tendrils	<i>Pisum sativum</i> L.	50.5	35.0	3.1	119	37	23
Green radish	<i>Raphanus sativus</i> L.	70.7	87.4	1.9	85	15	37
Arugula	<i>Eruca sativa</i> Mill.	45.8	19.1	1.6	131	68	44
Celery	<i>Apium graveolens</i> L.	45.8	18.7	2.2	131	70	32
Popcorn shoots	<i>Zea mays</i> L.	31.8	7.8	0.9	189	167	78
Golden pea tendrils	<i>Pisum sativum</i> L.	25.1	4.9	0.7	239	265	100

¹ Average values of vitamin C, E and K measured by Xiao et al. (2012).
² The daily intake recommended by the EFSA for adults is 60 mg for vit. C, 13 mg for vit. E and 70 µg for vit. K.

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What is the true value to consumers?

Microgreen Nutrients [2]	Vitamin E A-tocopherol (mg/100 g FW)	Provitamin A B-carotene (mg/100 g FW)	Vitamin C TAA (mg/100 g FW)	Vitamin K (mg/100 g FW)	Cost Per 100 g
Arugula	19.1	7.5	45.8	0.016	\$13.23
Celery	18.7	5.6	45.8	0.022	\$13.23
Cilantro	53	11.7	40.6	0.025	\$13.23
Magenta spinach	14.2	5.3	41.6	0.006	\$46.74

Raw Adult Vegetable Nutrients [4]	Vitamin E A-tocopherol (mg/100 g FW)	Provitamin A B-carotene (mg/100 g FW)	Vitamin C TAA (mg/100 g FW)	Vitamin K (mg/100 g FW)	Cost Per 100 g
Arugula	0.43	0.119	15	0.109	\$1.36
Celery	0.27	0.022	3.1	0.029	\$0.62
Cilantro	2.5	0.337	27	0.31	\$4.94
Spinach	2.03	0.469	28.1	0.483	\$1.46

Percentage Difference for Equal Cost Nutrients	Vitamin E A-tocopherol (Microgreen vs Green)	Provitamin A B-carotene (%) Microgreen vs Green)	Vitamin C TAA (% Microgreen vs Green)	Vitamin K (% Microgreen vs Green)
Arugula	455%	646%	31%	1.5%
Celery	323%	1188%	69%	3.5%
Cilantro	791%	1296%	56%	3.0%
Spinach	22%	35%	4.6%	0.04%

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Seed Selection

- Large selection of different types of microgreen seed (77 different types): <http://www.johnnyseeds.com/c-48-micro-greens.aspx>
- Large selection of Asian microgreen seed (107 different types) http://www.kitazawaseed.com/seeds_microgreens_baby_leaf.html

Seed Selection

- Purchase seed specifically for growing as microgreens
- Non-pelleted
- Untreated
- Or food grade





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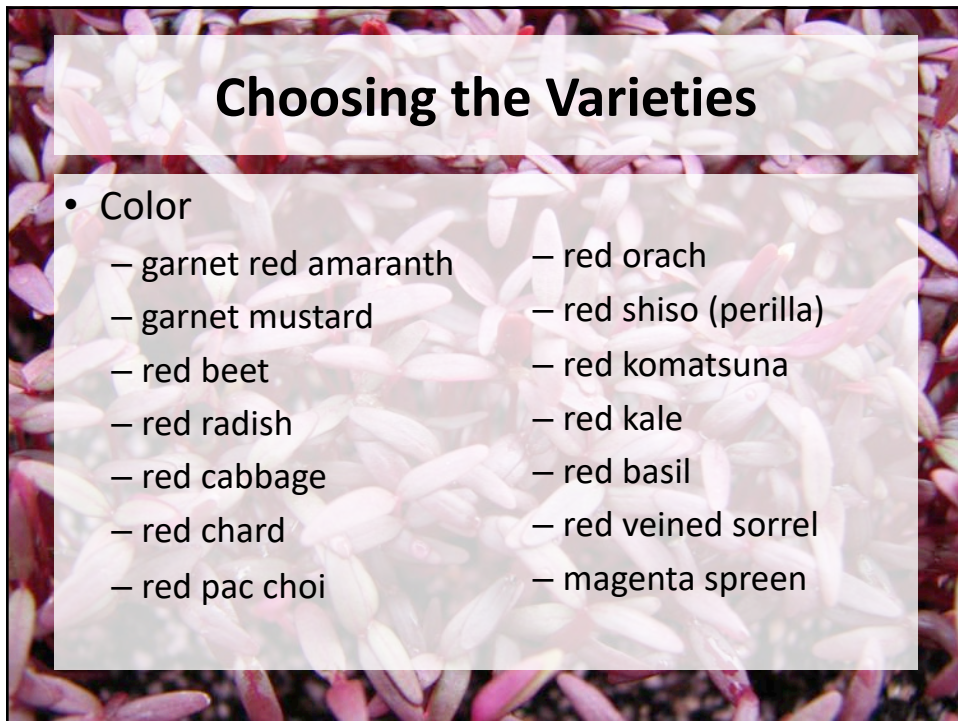
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Choosing the Varieties

- Color

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Choosing the Varieties

- Color
 - garnet red amaranth
 - garnet mustard
 - red beet
 - red radish
 - red cabbage
 - red chard
 - red pac choi
 - red orach
 - red shiso (perilla)
 - red komatsuna
 - red kale
 - red basil
 - red veined sorrel
 - magenta spreen

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Choosing the Varieties

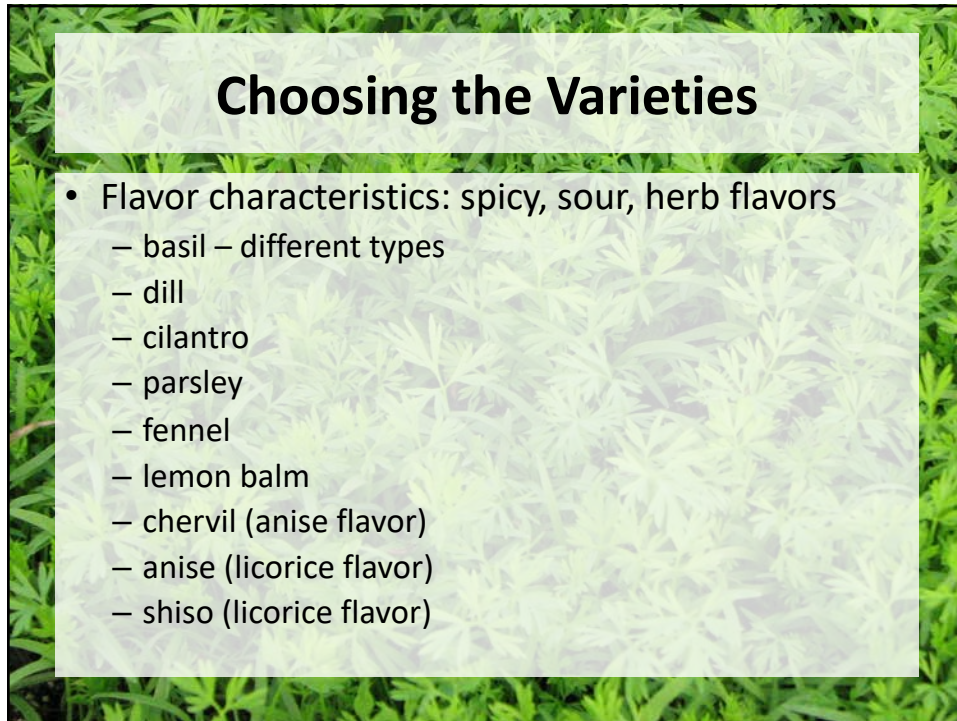
- Flavor characteristics: spicy, sour, herb flavors

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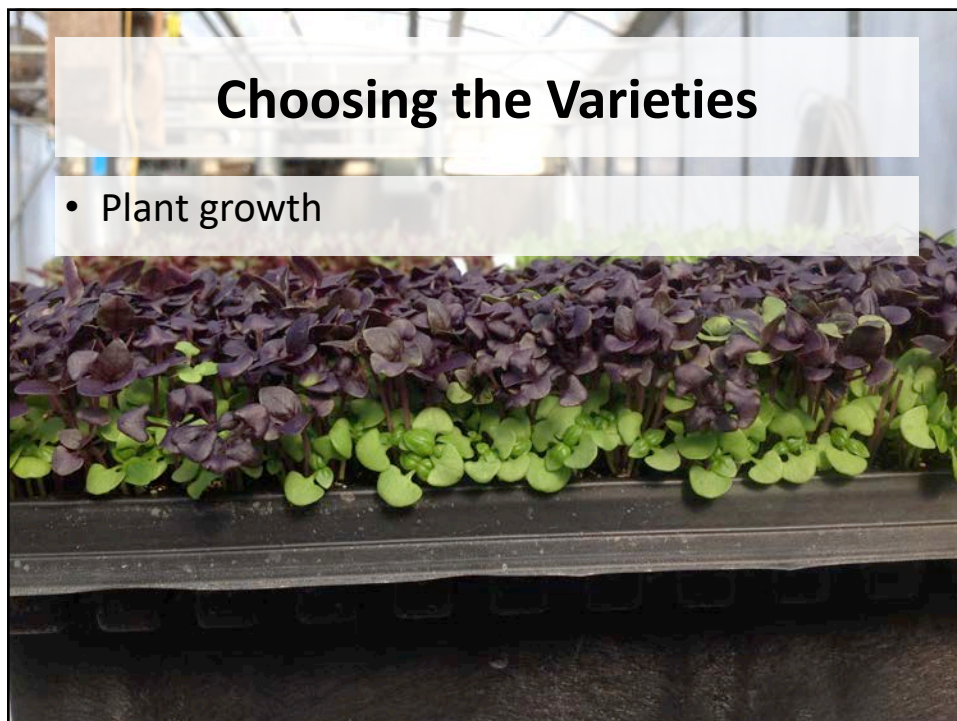
Choosing the Varieties

- Flavor characteristics: spicy, sour, herb flavors
 - spicy: daikon radish (or other Asian radishes), arugula, cress, spicy mix
 - mild spicy: radish, kale, mizuna, cabbage
 - scallions (onion flavor)
 - sorrel (lemon flavor)
 - citrus blend: lemon basil + sorrel + tangerine lace (marigold)
 - carrot (textured leaves, carrot flavor)
 - salad burnet (cucumber flavor)

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Choosing the Varieties

- Plant growth



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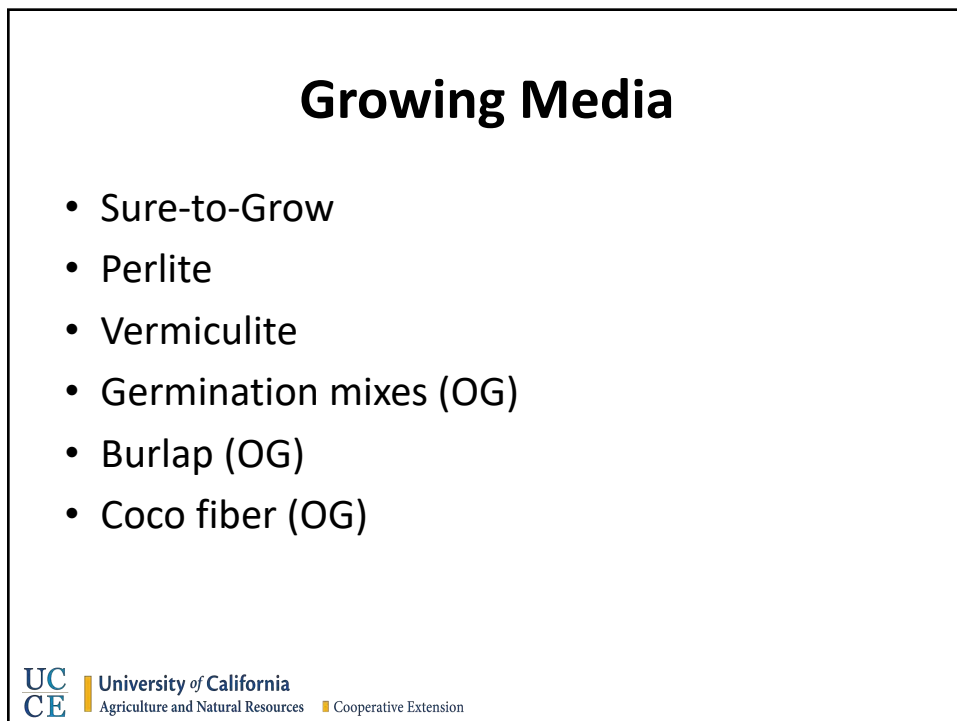
Growing Trays

- Types
- Quality
- Color
- Depth

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Sure-to-Grow

- Recycled PET plastic
- Sterile
- Inert
- pH neutral
- Dries out faster
- Best for NFT hydroponic systems



Sure-to-Grow





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Biostrate

- Lightweight
- pH balanced
- bio-based textile
- absorbs and retains water while providing an inert environment for dense healthy root development
- Compostable



Perlite and Vermiculite





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Burlap



www.crooking.com

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Coco Fiber



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Germination Mixes

- Fine grade
- Best for holding moisture
- Both organic and conventional options
- Some come with nutrients amended



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Used/Spent Media



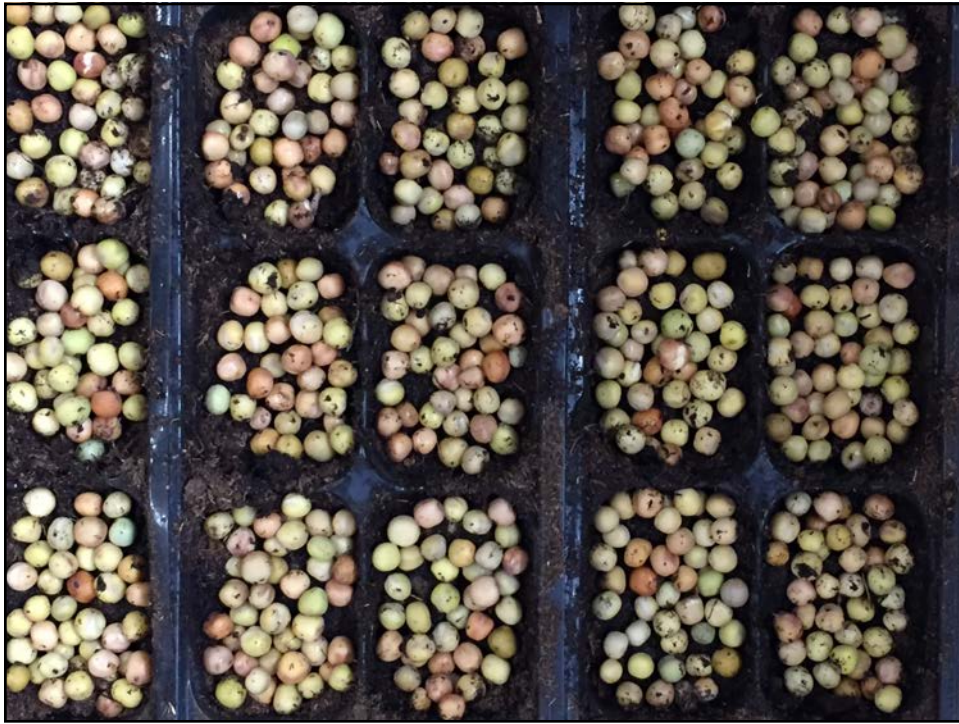
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Seeding Rate



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Production Management

- Watering: Best to bottom feed than overhead water



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Seeding and Watering Should be Uniform in the Entire Tray



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Crops in same tray should have similar germination rates!



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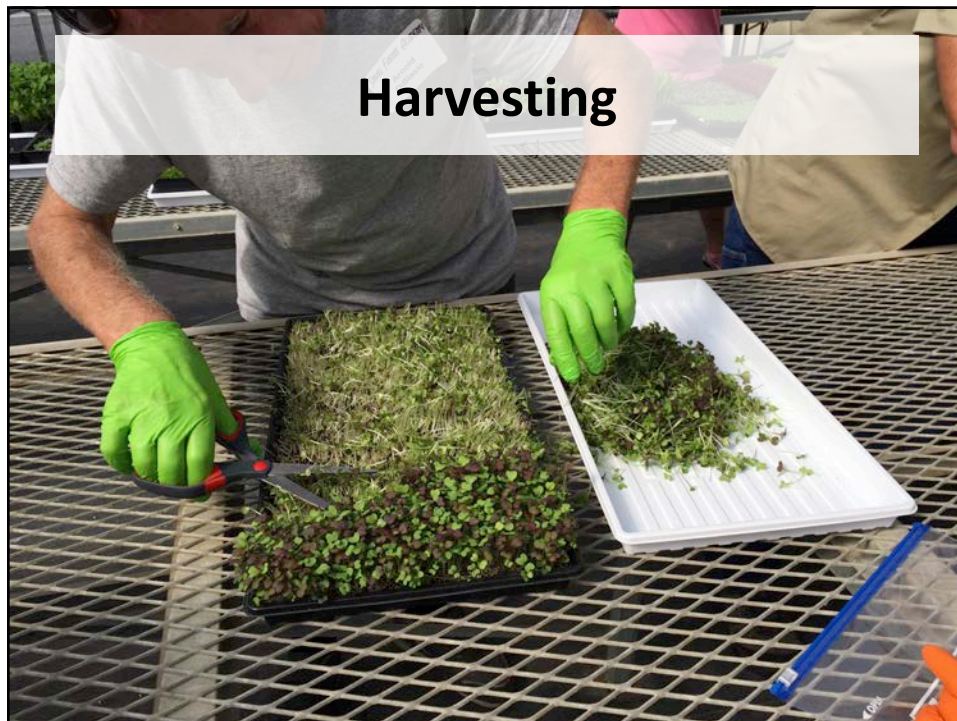
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Production Management

- Covered vs. uncovered seeds

Crop Type	Temperature Range (°F)	Days to Germination	Sunlight for Germination	Pre Soaking Seed
Amaranth – all types	60-90	3-4	Light cover	
Arugula – all types	60-75	5-7	Light cover	
Basil - all types	77-86	3-7	Light cover	
Beet	50 - 85	5-7	Light cover	
Borage	60-70	7-14	Light cover	
Broccoli	65-70	3-7	No cover	
Cabbage - red	65-75	3-10	No cover	
Carrot tops	45 - 85	10-14	Cover	
Celery		7-14	Cover	
Swiss Chard	50 - 85	5-7	Cover	
Chervil	70-85	7-14	Light cover	
Chive	60-70	7-10	Cover	
Cilantro	60-70	7-14	cover	
Cucumber	75 - 95	7-10	cover	

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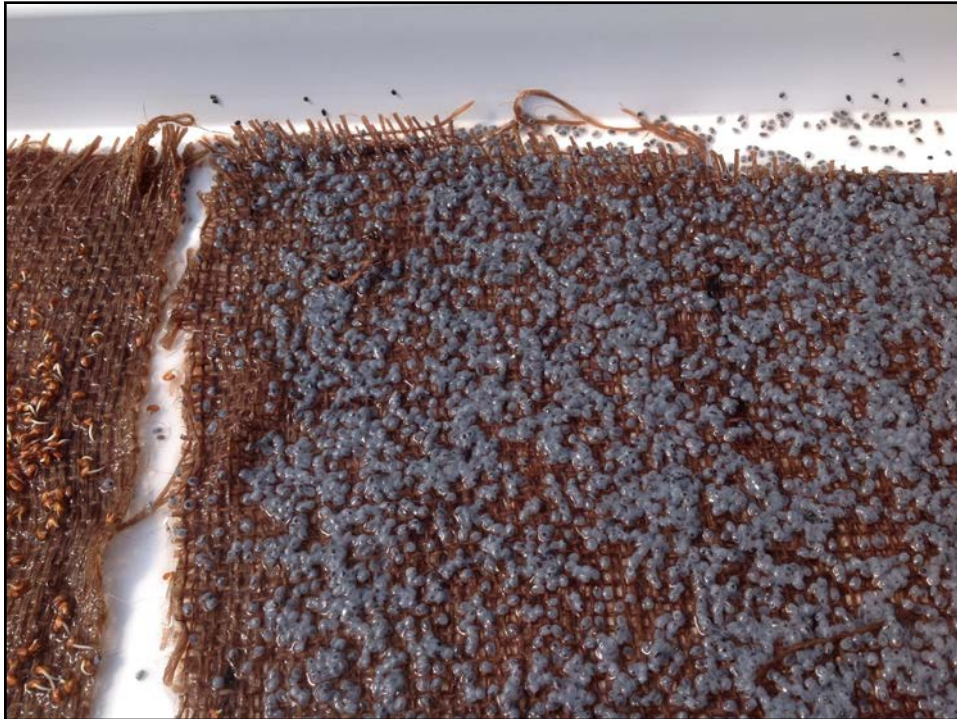


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The Bad and Ugly

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Economics of Microgreens Production

- Input costs are ~ \$2.46/ft² (irrespective of variety grown).
- Depending on variety, harvestable yield varies from 1.5 to >4 ounces/ft².
- Market prices depend on variety and production management.
- Market prices range from \$2.00 to \$6.00 per ounce.
- Profit margin ranging from 35% to 75%.
- Ultimate customer preferences for microgreen variety are based on the end use.

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Storage Quality

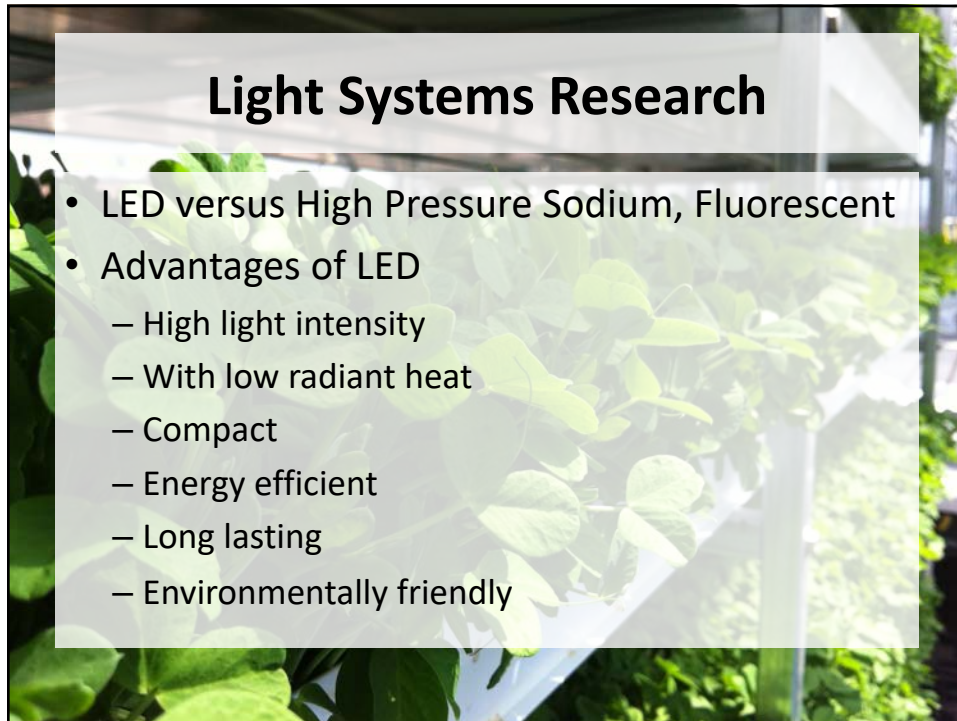
- Refrigerate immediately after harvesting
- Light exposure accelerated deterioration of radish microgreens, while dark storage maintained quality and prolonged shelf life
- Dark storage contributed to higher levels of carotenoids and antioxidant activity.
- Packaged radish microgreens stored at 1 °C (33.8 ° F) maintained acceptable quality on day 28 – extended shelf life

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Buckwheat Microgreens

- Gluten free
- High in protein, antioxidants, flavonoids, carotenoids, and vitamin E
- Very low shelf life
- Optimal storage temperature for maintaining quality of buckwheat microgreens is 5 °C

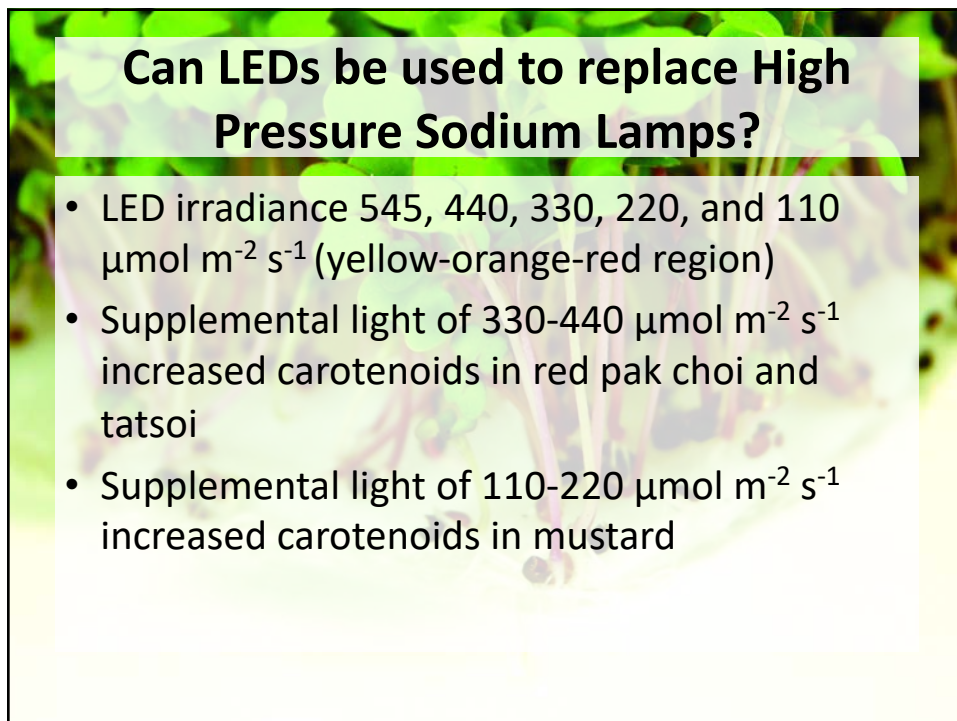
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Light Systems Research

- LED versus High Pressure Sodium, Fluorescent
- Advantages of LED
 - High light intensity
 - With low radiant heat
 - Compact
 - Energy efficient
 - Long lasting
 - Environmentally friendly

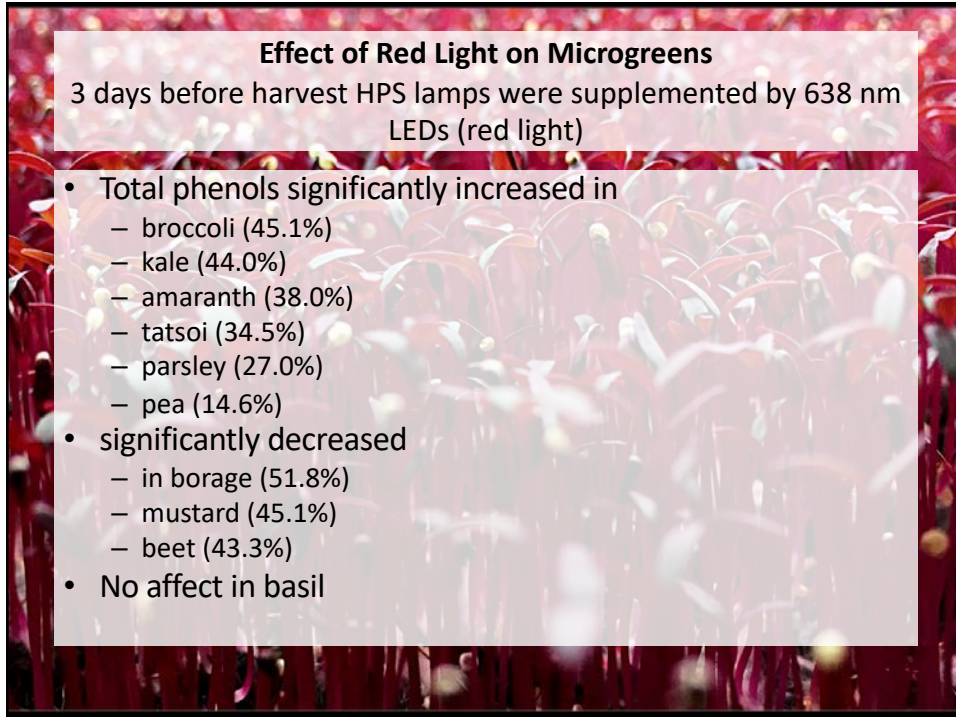
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Can LEDs be used to replace High Pressure Sodium Lamps?

- LED irradiance 545, 440, 330, 220, and 110 $\mu\text{mol m}^{-2} \text{s}^{-1}$ (yellow-orange-red region)
- Supplemental light of 330-440 $\mu\text{mol m}^{-2} \text{s}^{-1}$ increased carotenoids in red pak choi and tatsoi
- Supplemental light of 110-220 $\mu\text{mol m}^{-2} \text{s}^{-1}$ increased carotenoids in mustard

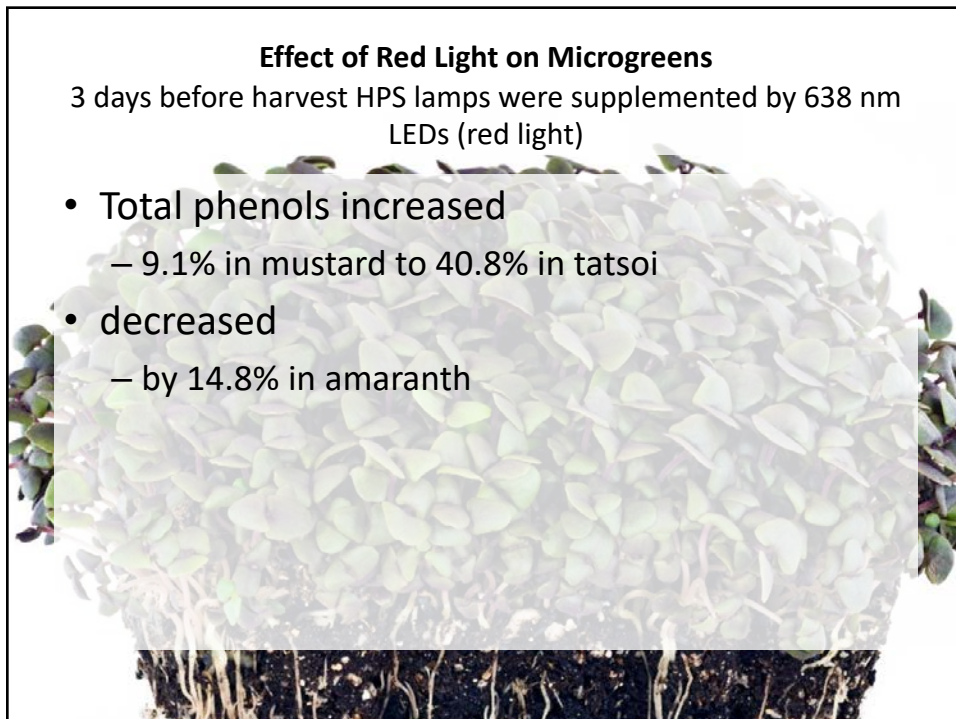
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Effect of Red Light on Microgreens
3 days before harvest HPS lamps were supplemented by 638 nm LEDs (red light)

- Total phenols significantly increased in
 - broccoli (45.1%)
 - kale (44.0%)
 - amaranth (38.0%)
 - tatsoi (34.5%)
 - parsley (27.0%)
 - pea (14.6%)
- significantly decreased
 - in borage (51.8%)
 - mustard (45.1%)
 - beet (43.3%)
- No affect in basil

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Effect of Red Light on Microgreens
3 days before harvest HPS lamps were supplemented by 638 nm LEDs (red light)

- Total phenols increased
 - 9.1% in mustard to 40.8% in tatsoi
- decreased
 - by 14.8% in amaranth

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Good Water Farms

npr.org