Pick and Eat Crop Testing: Dwarf Tomato and Pepper as Candidate Space Crops

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Background

- Current approaches to providing foods in space rely totally on stowage and resupply
- Other than small scale tests with Russian Svet chamber on Mir, the Russian Lada chamber on ISS, and recently with NASA's Veggie unit, few fresh foods have been grown in space.
- The ability to provide fresh foods in situ for exploration could improve diet acceptability, nutrition, and crew well-being
- Future long durations missions will require food (crop) production capabilities to achieve higher levels of autonomy and Earth-independence.

Objective

- The intent of these studies was to compare tomato and pepper cultivars that have short stature, high yields, desirable nutritional attributes, and acceptable taste for use as possible “pick-and-eat” crops in space

Experimental Set-Up

- All plants grown in plant growth chambers with fluorescent lighting:
  - 16-h photoperiod / 8-h dark period
  - 300 µmol m^{-2} s^{-1} (~ 60 W m^{-2} 400-700 nm)
  - 22°C temperature
  - 50% relative humidity
  - 1500 ppm CO_2
- Plants grown from seed in 4-in (10-cm) square pots
  - 7:3 Fafard #2B potting mix with Turface (arcillite)
  - 10 g L^{-1} of 18-6-8 (N-P-K) time release fertilizer
  - Ca. 60 days age, plants also watered 3 X daily with nutrient solution (modified ½ strength Hoagland / Arnon)

Cultivars Tested

- Tomatoes (*Solanum lycopersicum* L.):
  - First Test:
    - Scarlet Sweet ‘N’ Neat, Red Robin, Patio Princess, Tumbler, Tiny Tim, Mohamed
  - Down-Select / Second Test:
    - Sweet ‘N’ Neat, Red Robin, Mohamed
- Pepper (*Capsicum annuum* L.):
  - First Test:
    - Red Skin, Fruit Basket, Cajun Belle, Chablis, Sweet Pickle, Pompeii
  - Down-Select Second Test:
    - Red Skin, Fruit Basket, Pompeii

Dwarf Tomato - Candidates

- ‘Red Robin’ tomato
- ‘Sweet ‘n’ neat’ tomato
- ‘Mohamed’ tomato
- ‘Patio Princess’ tomato
- ‘Tiny Tim’ tomato
- ‘Tumbler’ tomato

Tomatoes in Growth Chambers

Dwarf Pepper- Candidates

- ‘Chablis’ pepper
- ‘Pompeii’ pepper
- ‘Fruit Basket’ pepper
- ‘Red Skin’ pepper
- ‘Cajun Belle’ pepper
- ‘Sweet Pickle’ pepper

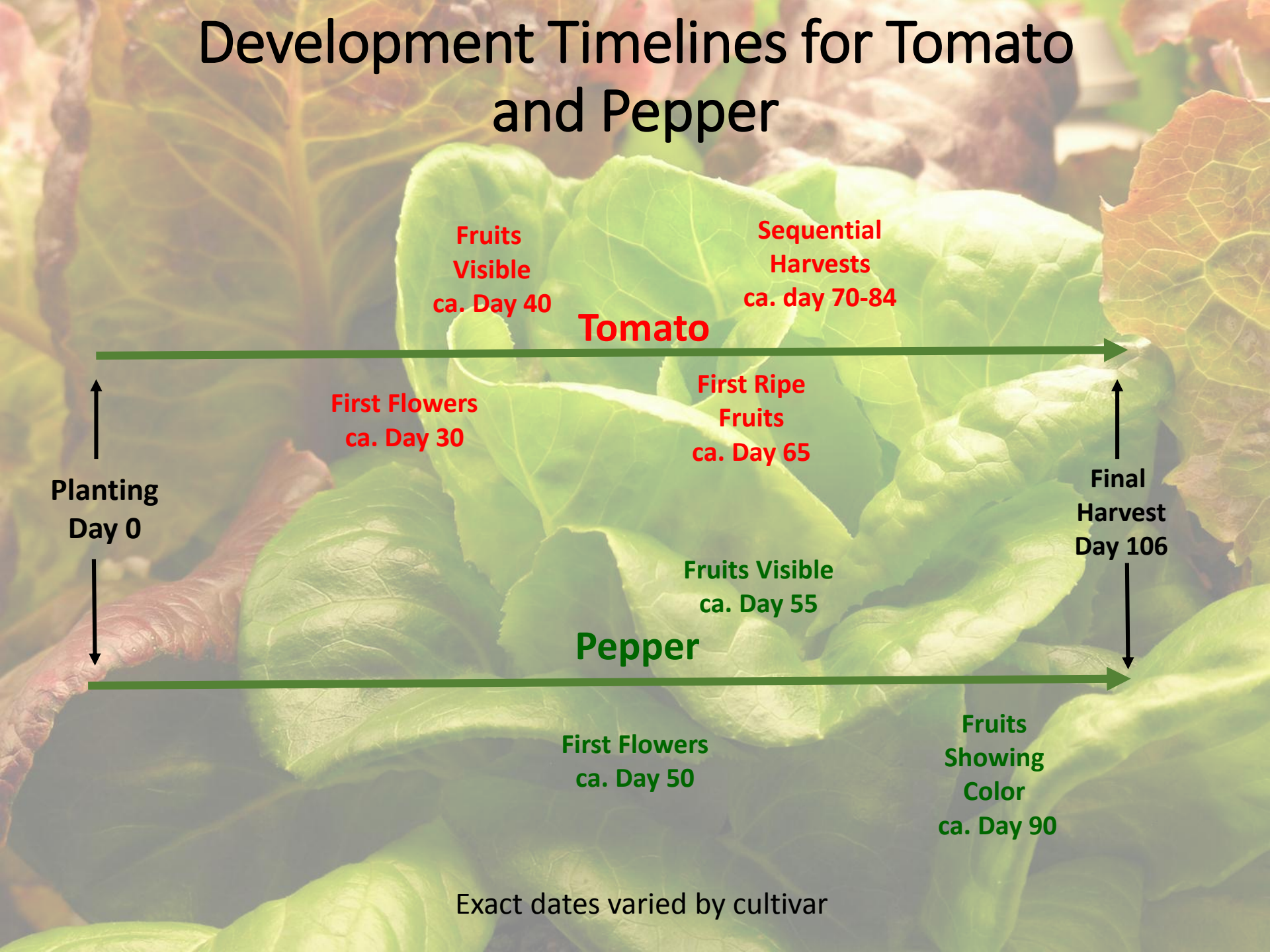
Peppers in Growth Chambers

Selection Criteria

- Horticultural factors
  - Canopy area, height, # fruit/plant, total fruit mass, days to first fruit, percent moisture, [1]trueness to type, [2]mass per fruit
- Nutritional factors
  - Composition of key elements (K, Fe, Ca, Mg)
  - Beneficial phytonutrients (Phenolics, Antioxidants, Anthocyanins ([2]ripe and unripe fruit), Vitamin K, Lutein, Zeaxanthin, [1]Lycopene)
- Organoleptic factors
  - 9-pt Hedonic Scale: Overall taste, Appearance, Color, Aroma, Flavor, [2]Texture
  - 5-point Just About Right Scale: Sweetness, Juiciness, [1]Tartness, [2]Astringency

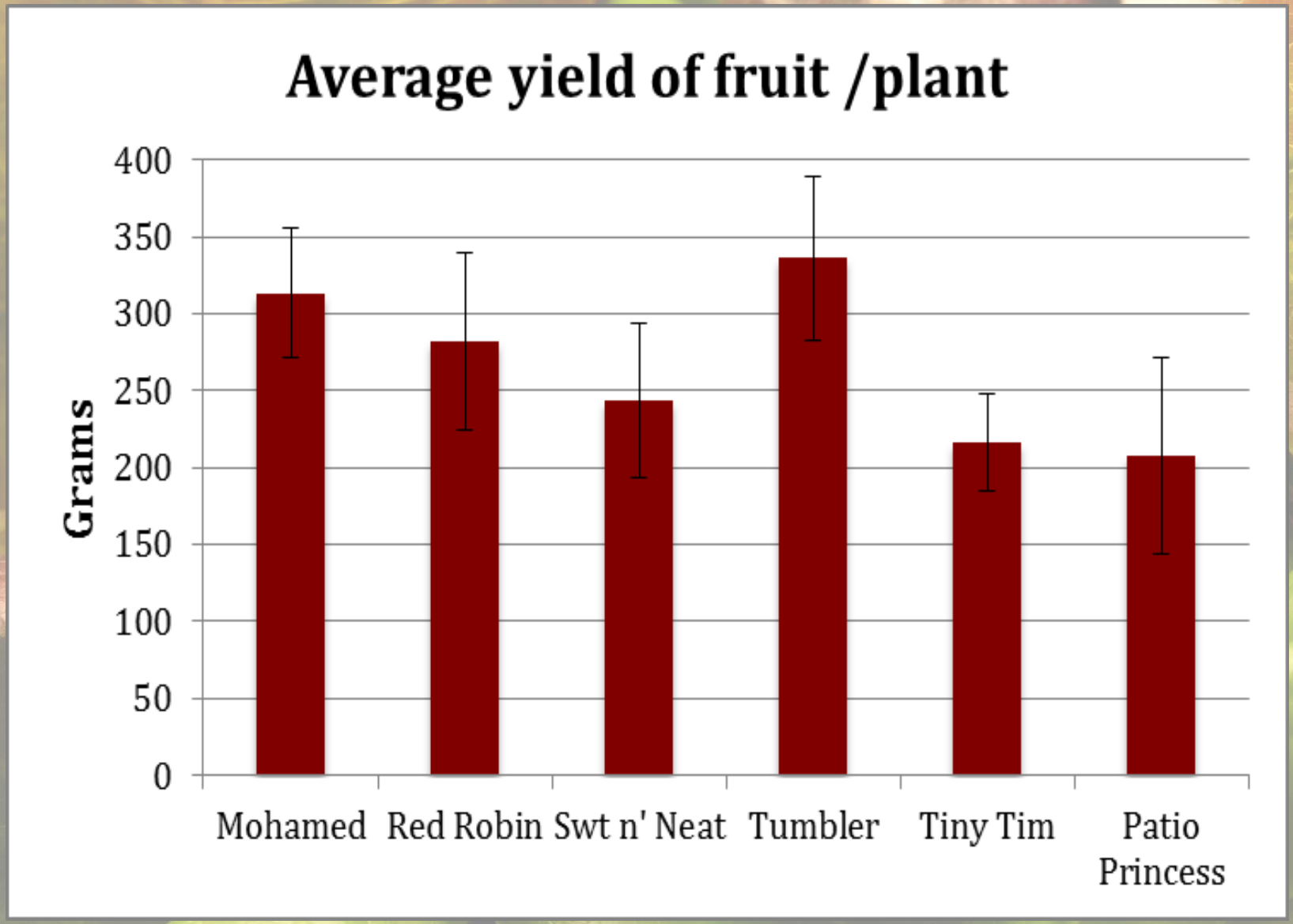
([1] tomato, [2]pepper)

Development Timelines for Tomato and Pepper

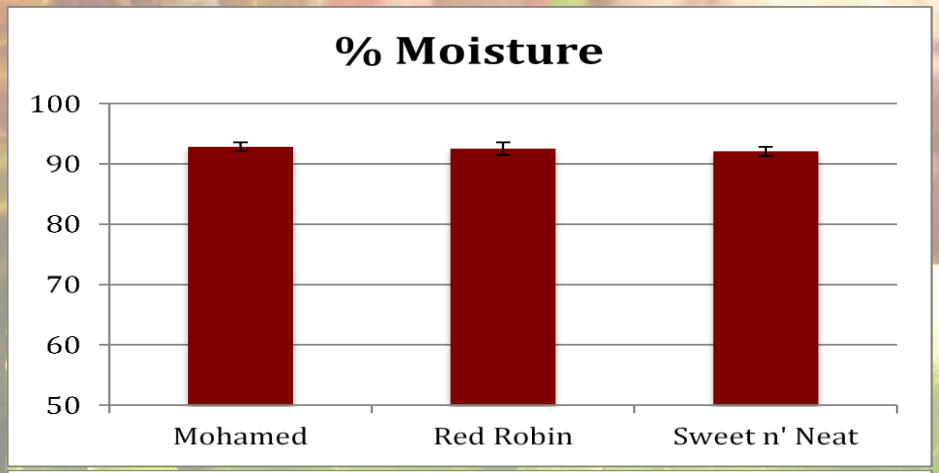


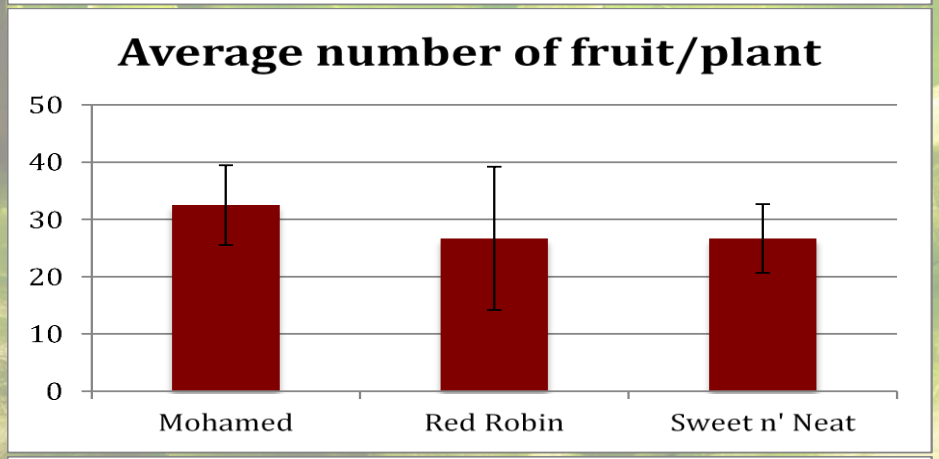
Exact dates varied by cultivar

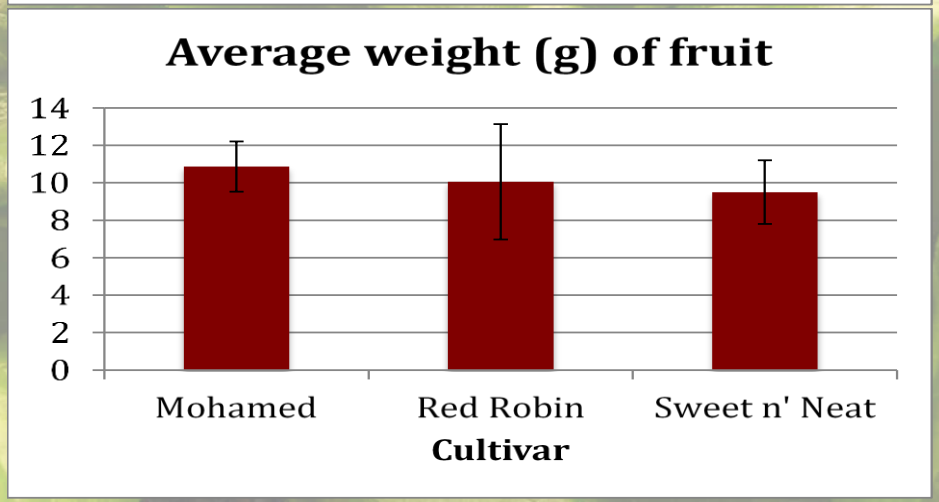
Yields: Tomato Initial Down-Select



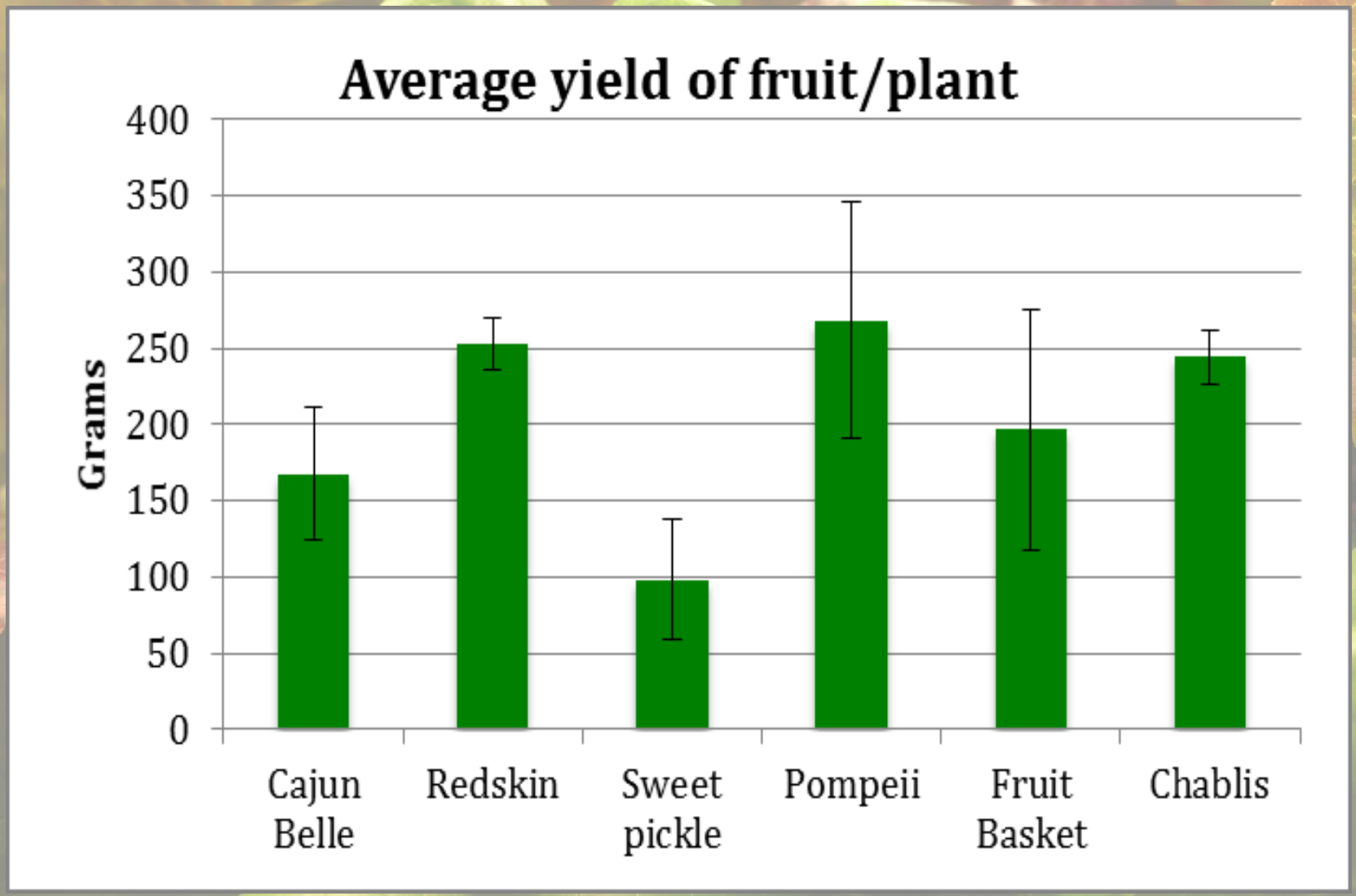
Tomato Yields Three Best Cultivars



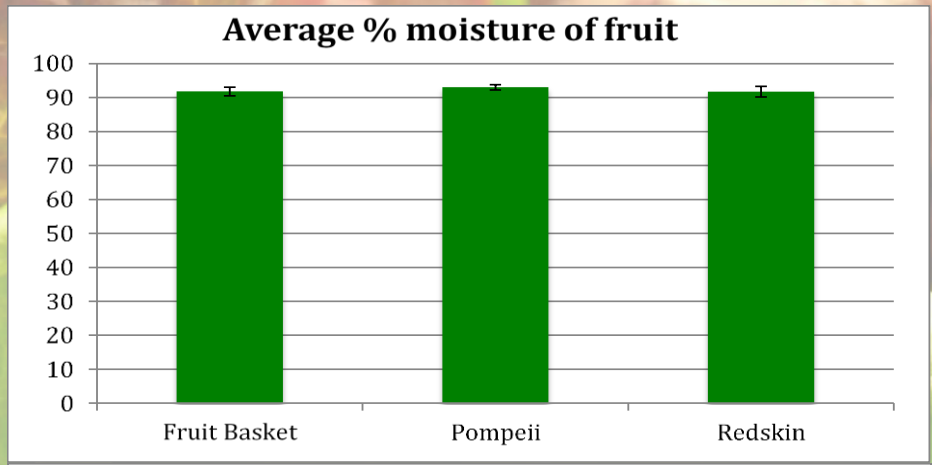


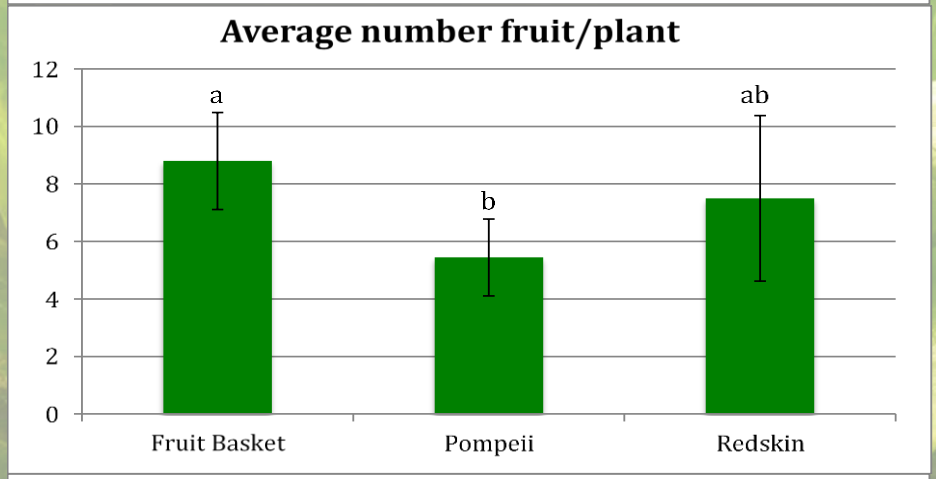


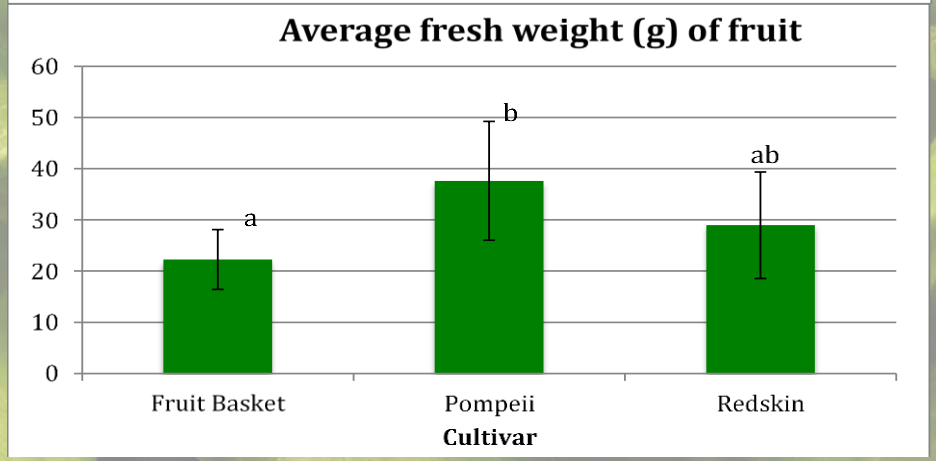
Yields: Pepper Initial Down-Select



Pepper Yields Three Best Cultivars







Nutrient Analysis: Tomato

	Phenolics	ORAC	Lyco-pene	Antho-cyanin	Lutein	Zeaxanthin	Vit. K
Cultivar	µg/g	µmol TE / g	mg/g				mg/100g
Red Robin	7.72	71.32	34.99	1.58	1.85	0.03	**19.75 a**
Mohamed	7.17	74.70	36.98	2.00	1.77	0.03	18.85 ab
Sweet 'N' Neat	7.83	72.18	42.02	1.61	1.46	0.04	14.45 b

Elemental Analysis: Tomato

	Ca	Fe	K	Mg
Cultivar	(μg / g)			
Red Robin	947	BDL	**24672 a**	**1440 a**
Mohamed	859	BDL	23740 ab	1375 ab
Sweet n' Neat	781	8.09	22329 b	1210 b

Nutrient Analysis: Pepper

	Phenolics	ORAC	Lutein	Zeaxanthin	Vit. K
Cultivar	µg/g	µmol TE/g	mg/g		mg/100g
Pompeii	12.29	94.49 ^{b}	94 ^{b}	0.06 ^{ab}	113
Fruit Basket	12.56	**128** $^{\mathbf{cb}}$	**128** $^{\mathbf{cb}}$	0.03 ^{a}	116
Red Skin	**13.27**	111 ^{cb}	111 ^{cb}	**0.08** $^{\mathbf{b}}$	**112**
Cajun Belle	14.42	150 ^{a}	151^{a}	0.07 ^{ab}	119
Chablis	14.39	137 ^{ac}	137 ^{ac}	0.04 ^{ab}	100

Elemental Analysis: Pepper

	Ca	Fe	K	Mg
Cultivar	(µg/g)			
Pompeii	**1135** ^{b}	BDL	21154	1165 ^{ab}
Fruit Basket	872 ^{b}	BDL	**21819**	1085 ^{b}
Red Skin	793 ^{b}	BDL	19290	**1203** ^{ab}
Cajun Belle	1297 ^{ab}	BDL	19904	1450 ^{ab}
Chablis	1898 ^{a}	BDL	20331	1500 ^{a}

Sensory Analysis

JSC Taste Test Panels

Sensory Evaluation Tomato

Attribute	Red Robin	Mohamed	Sweet 'N' Neat
Overall Acceptability	7.12 ± 1.75	7.62 ± 1.18	6.88 ± 1.82
Appearance	8.15 ± 0.82	8.47 ± 0.56	8.03 ± 1.00
Color Intensity	8.00 ± 8.18	8.29 ± 0.72	8.06 ± 1.07
Aroma	6.44 ± 1.78	6.24 ± 1.58	6.18 ± 1.64
Flavor	7.06 ± 1.79	7.50 ± 1.44	6.65 ± 2.14
Texture	6.35 ± 2.44	7.91 ± 1.14	6.79 ± 2.16

9-point hedonic scale; values represent means SD (n = 34)

Sensory Evaluation Tomato

Attribute	Red Robin	Mohamed	Sweet 'N' Neat
Sweetness	2.88 ± 0.77	2.82 ± 0.76	2.71 ± 0.87
Tartness	2.82 ± 0.72	2.62 ± 0.70	2.85 ± 0.78
Juiciness	3.44 ± 0.75	3.06 ± 0.24	3.06 ± 0.55

5-point "just about right" scale; values represent means SD (n = 34)

Sensory Evaluation Pepper

Attribute	Pompeii	Red Skin	Fruit Basket
Overall Acceptability	7.91± 0.68	6.77± 1.54	6.23± 1.82
Appearance	8.14 ± 1.08	7.09 ±1.72	8.18 ± 0.96
Color Intensity	8.23 ±1.11	7.64 ± 1.92	8.27 ± 1.03
Aroma	7.59 ± 1.22	6.82 ± 1.44	6.82 ± 1.59
Flavor	7.73 ± 0.88	6.77 ±1.57	5.73 ± 2.00
Texture	8.27 ± 0.63	7.95 ±1.00	7.82± 1.05

9-point hedonic scale; values represent means SD (n = 34)

Sensory Evaluation Pepper

Attribute	Pompeii	Red Skin	Fruit Basket
Astringency / Bitterness	2.50 ± 0.96	3.00 ± 0.98	3.82 ± 0.73
Sweetness	2.68 ± 0.57	2.27 ± 0.77	1.95 ± 0.79
Juiciness	3.00 ± 0.31	3.00 ± 0.31	2.86 ± 0.35

5-point “just-about-right” scale; values represent means SD (n = 34)

Conclusions

- Six cultivars of tomato and six of pepper were grown in controlled environments to simulate ISS like conditions
- Three cultivars of each were selected from the first test, based primarily on fruit yield and growing height
- Harvested fruits were also analyzed for elemental composition and nutrients such as Vit K, Lutein, Zeaxanthin, Lycopene, and Anthocyanin
- Test were repeated with the down-selected cultivars and harvested fruits analyzed for organoleptic qualities
- Tomato cv. Red Robin and Pepper cv. Pompeii are recommended for further testing as possible “pick-and-eat” crops for ISS

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