Sinks-Sources-Sugars-Starches: The 4S's of Pumpkin Growth

Presented by:

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GPC Big Show, 2017

Deer Park, WI

–Competitive grower since 2000 (PB 1422lbs)

–Founder & President of the St. Croix Grower's Association & Stillwater HarvestFest

–B.S. Biotechnology (plant science emphasis)

–M.S. Nutrition

–Professional Certificate in crop science (soil fertility emphasis)

–Certified Crop Advisor (WI)

Explore the mechanisms of carbon partitioning (sink/source relations) to help us grow bigger pumpkins

-understand the process
-understand what affects the process
-identify what you can do to impact the process

The Big Picture

1. Leaves make sugar
2. Sugar moves to the pumpkin
3. Pumpkin converts sugar to starch

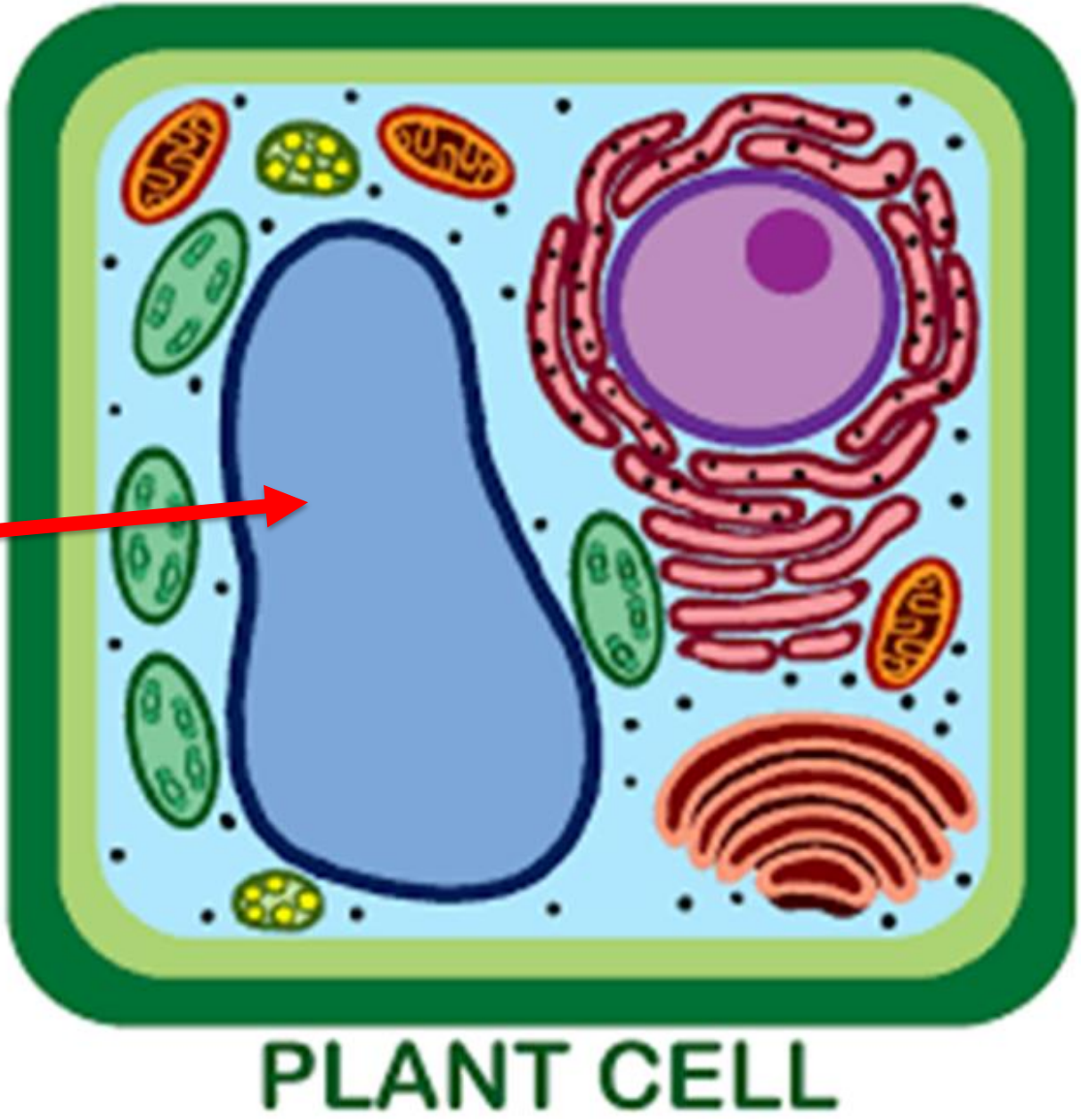
More of this  = bigger pumpkins.

A pumpkin is >90% water

Of the remaining ~10%, ~85% is starch

2000lb Pumpkin=
1800lbs water
170lbs starch
30lbs other stuff

Starch & Water get stored here:



How the heck do we get a marble to turn into a small car in ~100 days???

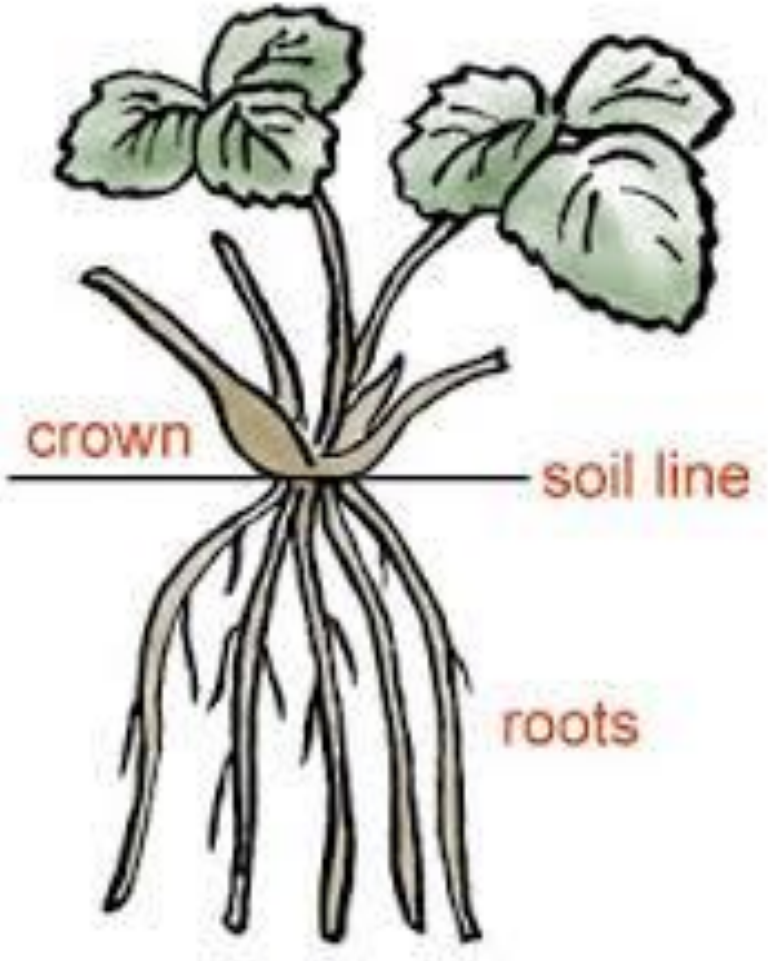
Let’s start with some terminology


–Xylem (water up)
–Phloem (sugar down)

–A pumpkin growing 40lbs/day will move >5 gallons of water through these tubes

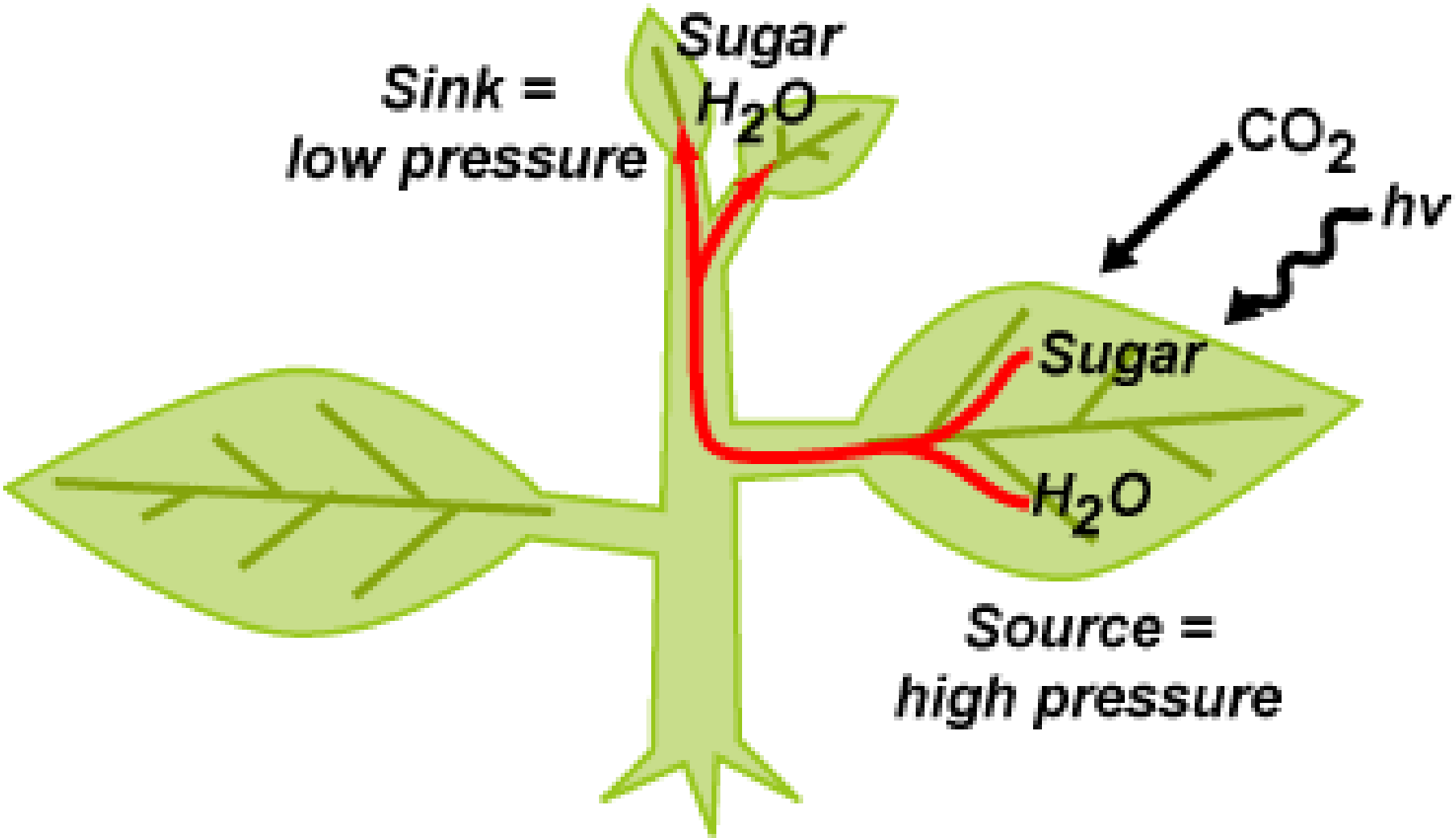

–Xylem (water up)
–Phloem (sugar down)


tump


crown
soil line
roots

–**Sources**: Leaves- Make sugar

–**Sinks**: Roots, Shoots, Froots- eat sugar



Fruit growth boils down to three fundamental variables:

- Source strength
  - (enough leaves, photosynthesis, sugar production?)
- Vascular transport volume/speed
  - (enough pipes with fast enough flow to move sugar?)
- Sink strength
  - (enough consumption of water/sugar?)

Source Strength is tied to plant health

- Pumpkins do not appear to be “source limited” under healthy conditions
- Keeping leaves greener for longer ensures limiting factor is not source-related
- Promote plant youth with auxin-friendly pruning strategies
- Promote root growth

Vascular transport capacity is inherently genetically built in

- The plumbing is apparently not a limiting factor in pumpkin growth
- AG's have larger vascular area cross-section
- Small pipes-faster flow.
- Large pipes-slower flow.

Sink Strength is where the action is

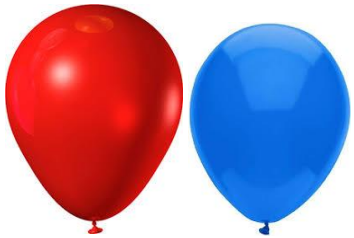
Sink Strength=sink size x sink activity

- Sink activity is taking sugar out of phloem and converting to starch

- What drives sugar>starch conversion?

- Fruit Cell number & cell expansion

Increasing Cell Number (more balloons)



Genetically?

Environmentally

Superior crosses? (high cross-weight ave)

Plant Growth Regulators (Anthesis)

Maximize cell number by selecting top genetics: Cross Weight Average

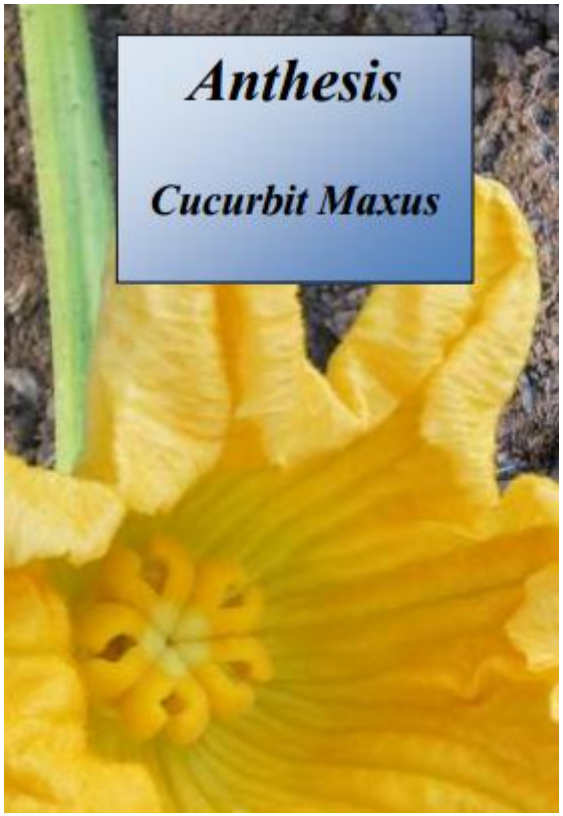
- 2pt formula= female weight + male weight/2
  - 1944 Connolly (2230 Wal + 2145 Mc/2=2187 CWA)

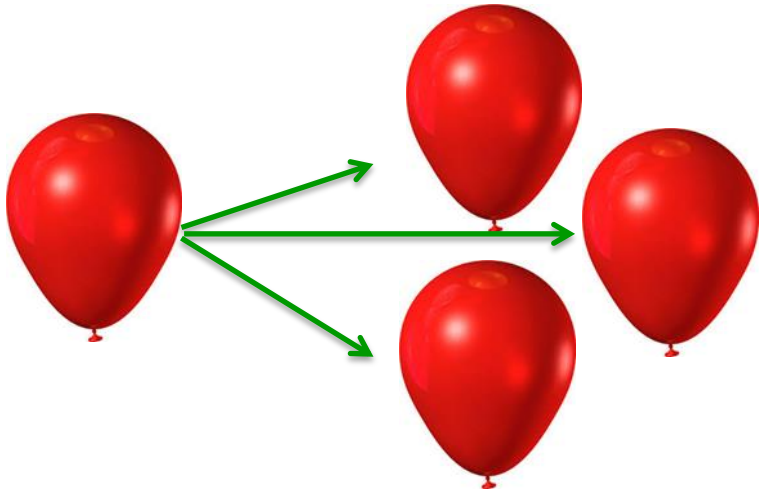
- 3pt formula= female weight + male weight + progeny weight/3
  - 2624 Wil (2145 Mc + 1872 Wil + 2624/3=2214 CWA)

- Plant breeders have been practicing this for centuries (best x best)

GPC place	weight	grower	F	M	2pt CWA	3pt CWA
1	2,624.60	Willemijns, Mathias	2145	1872	2009	2214
2	2,261.00	Wallace, Dick	2009	1790	1900	2020
3	2,252.30	Paton, Ian & Stuart	1975	1781	1878	2003
EXH	2,157.00	Paton, Ian & Stuart	2096	1781	1939	2011
4	2,106.00	Schmit, Mike	1385.5	Open	-	-
5	2,095.50	Willemijns, Mathias	1684	1872	1778	1884
6	2,075.50	Connolly, Steve	1961	2230.5	2096	2089
7	2,066.00	Geddes, Steve	2145	1727.5	1936	1980
8	2,063.50	Willemijns, Mathias	1872	2145	2009	2027
9	2,058.50	Rose, Jerry	1585	1730	1658	1791
10	2,048.10	Willemijns, Mathias	1861	1872	1867	1927
11	2,047.00	Sippel, Dereck	1338	1756	1547	1714
12	2,004.00	Vander Wielen, Pete	2145	2017	2081	2055
13	1,986.40	Wuersching, Matthias	1781	2096	1939	1954
14	1,969.00	Haist, Karl	1985	1725	1855	1893
15	1,964.50	Haist, Karl	1806	1725	1766	1832
EXH	1,949.50	Paton, Ian & Stuart	1781	2096	1939	1942
16	1,948.50	Werner, Quinn	1585.5	1461	1523	1665
17	1,944.50	Pugh, Russ	2145	2109	2127	2066
18	1,944.00	Conolly, Steve	2230	2145	2188	2106
19	1,938.00	Zywiec, Lorelee	2230	2109	2170	2092
20	1,937.00	Urena, Leonardo	2145	2230	2188	2104

Applied plant growth regulators may increase cell number

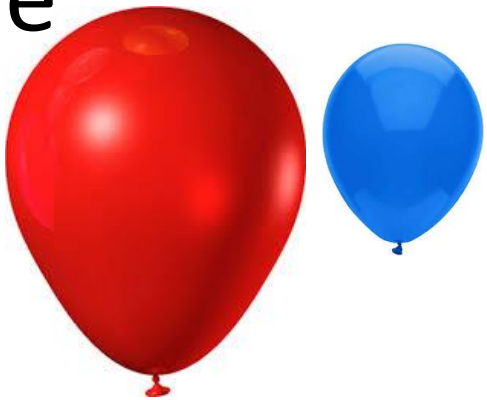




What is "*Anthesis*"?

Anthesis is a combination of two plant hormones selected to increase the rate and duration of cell division in a pumpkin or tomato to result in a larger fruit at harvest.

Increasing Cell Volume (larger balloons)



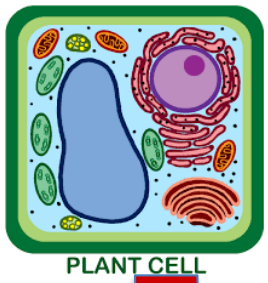
Genetically?

Environmentally

Superior crosses?
(high cross-weight ave)

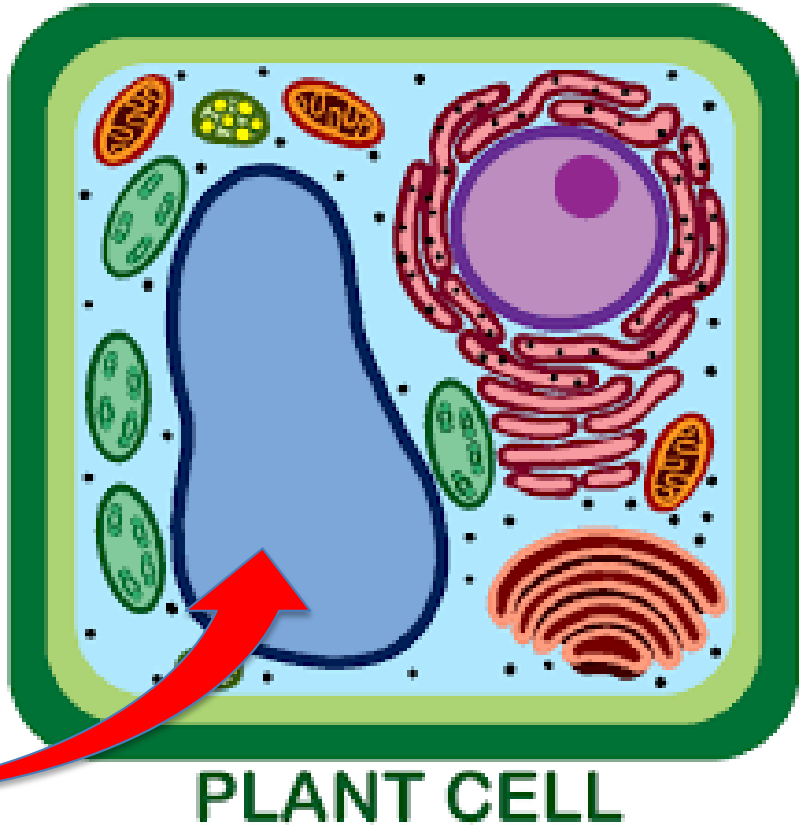
Fertility
Hydration
Pruning
PGRs

Weight Gain=Increasing Cell Volume



x 10,000

Size increase



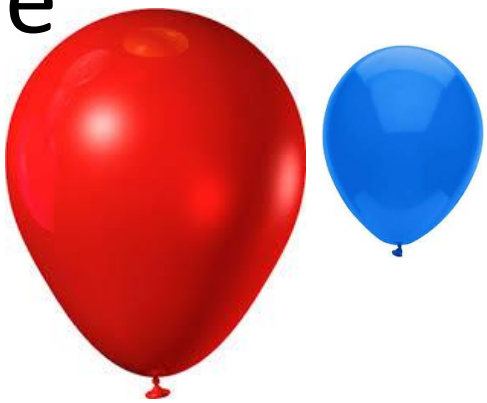
Water, Sugar, Starch

Pumpkin Volume increases ~2.2 million fold (assuming 200” circ)

Volume= 1 CM3

Volume= 2,210,000 CM3

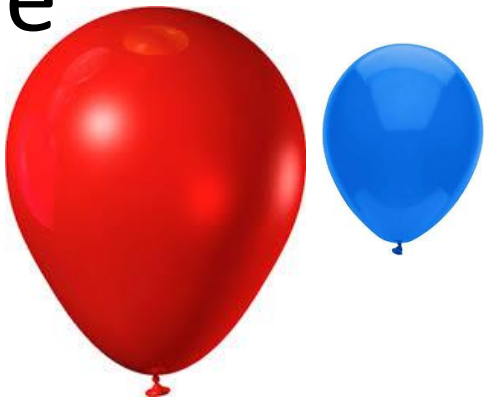
Increasing Cell Volume (larger balloons)



Genetically

Superior crosses (high cross-weight ave) → **Biggest Pumpkins have genetic blueprint for biggest pumpkin progeny**

Increasing Cell Volume (larger balloons)

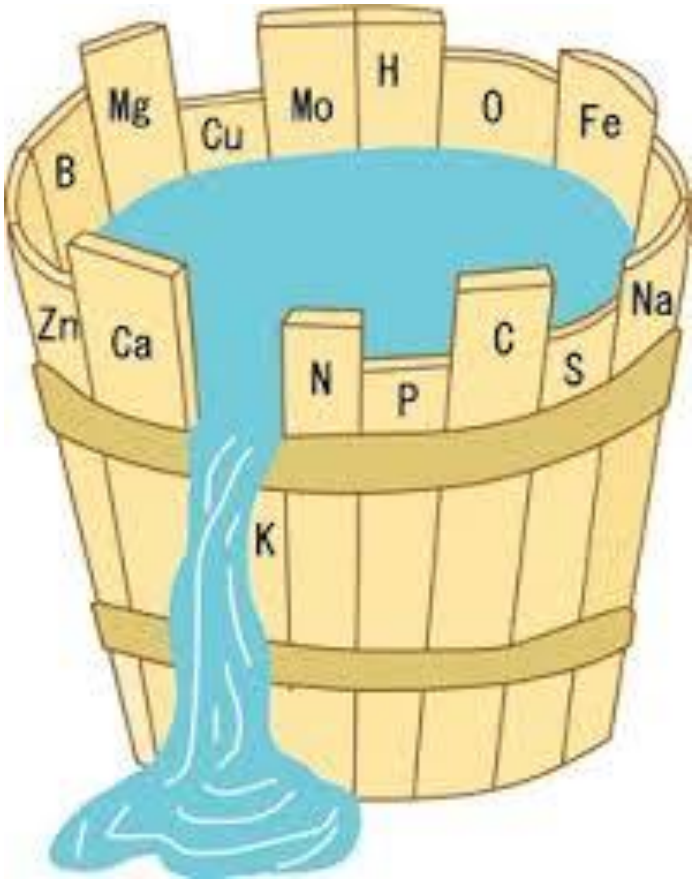


Environmentally

Variables we control

Fertility
Hydration
Pruning
PGRs

Fertility-Liebig's law: lowest level nutrient caps pumpkin's potential



Soil Test Guidelines For Giant Pumpkins

Parameter	Range	Raise with	Decrease with	Notes
pH	6.5-7.0	Lime	Sulfur	
Organic Matter	3-10%	manure, compost, leaves		
Cation Exchange Capacity (CEC)	10-20 meq/100g	organic matter, humic acid		
Base Saturation				
% K	5-9%	See Potassium		
% Mg	12-18%	See Magnesium		
% Ca	66-75%	See Calcium		
% H	0-12%			
% Na	<1.5%		Leaching	
Nitrogen (N)	60-100lbs/acre (30-50ppm)	Urea, ammonia, N-fixing bacteria	Leaching	
Phosphorous (P)	150-400 lbs/acre	Rock Phosphate		
Potassium (K)	1000 lbs/acre			
Calcium (Ca)	2500-4500 lbs/acre	Lime, Gypsum		Lime increases pH, gypsum does not, gypsum will also raise S
Magnesium (Mg)	300-600 lbs/acre	Magnesium Sulfate	Boost Calcium	Also raises S
Sulfur (S)	40-100lbs/acre (20-50ppm)	Sulfur, Gypsum		Gypsum will also raise Ca
Zinc (Zn)	20-40lbs/acre (10-20ppm)			
Manganese (Mn)	50-80lbs/acre (25-40ppm)	Foliar $MnSO_4$, decrease pH	increase pH	non-foliar application not recommended
Iron (Fe)	100-400lbs/acre (50-200ppm)	Foliar, decrease pH		non-foliar application not recommended
Copper (Cu)	2-5ppm			
Boron (B)	1-2ppm	Borax		
Sodium (Na)				No Supplement Necessary

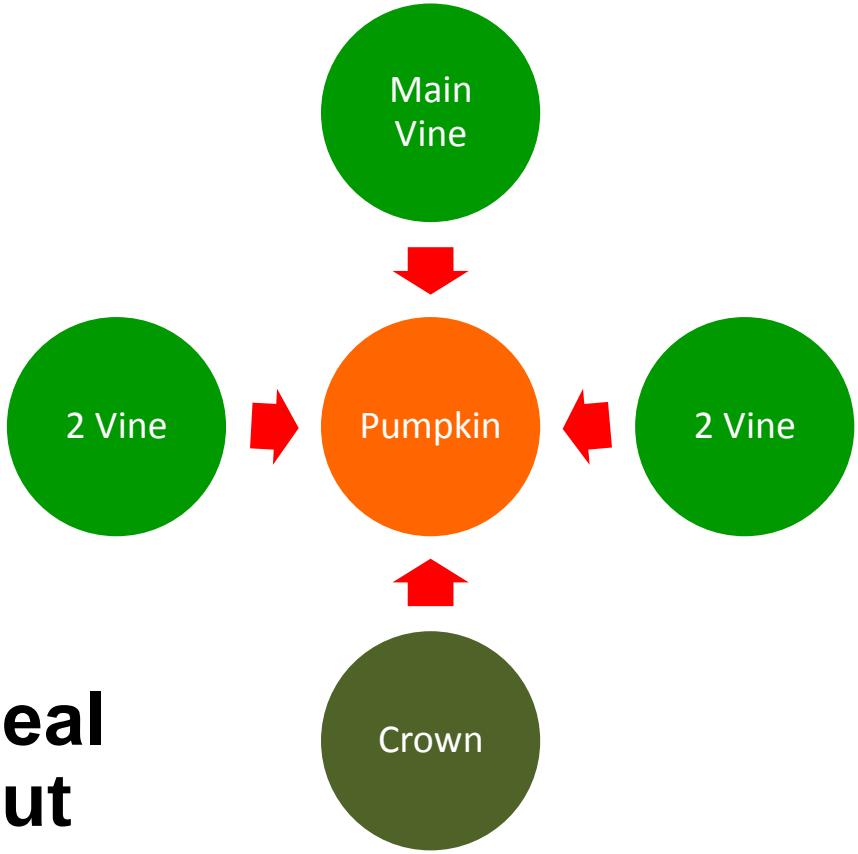
The information provided serves as a guideline only and does not replace the expertise of a qualified agronomist. The ranges provided are a compilation generated from multiple sources, including Don Chambers soil study on Atlantic Giants, trained agronomists, and laboratory-reported reference ranges.

Hydration: Goldilocks Principle

–A role for tensiometers?

Pruning Strategies

- Sources preferentially allocate sugar to closest sink



“Hub & Spoke” is ideal model for plant layout


I favor preservation of secondaries in proximity of fruit

Main Vine: To prune or not to prune?

Joe says “no”

MV Tip is a primary source of the hormone Auxin for the plant and fruit

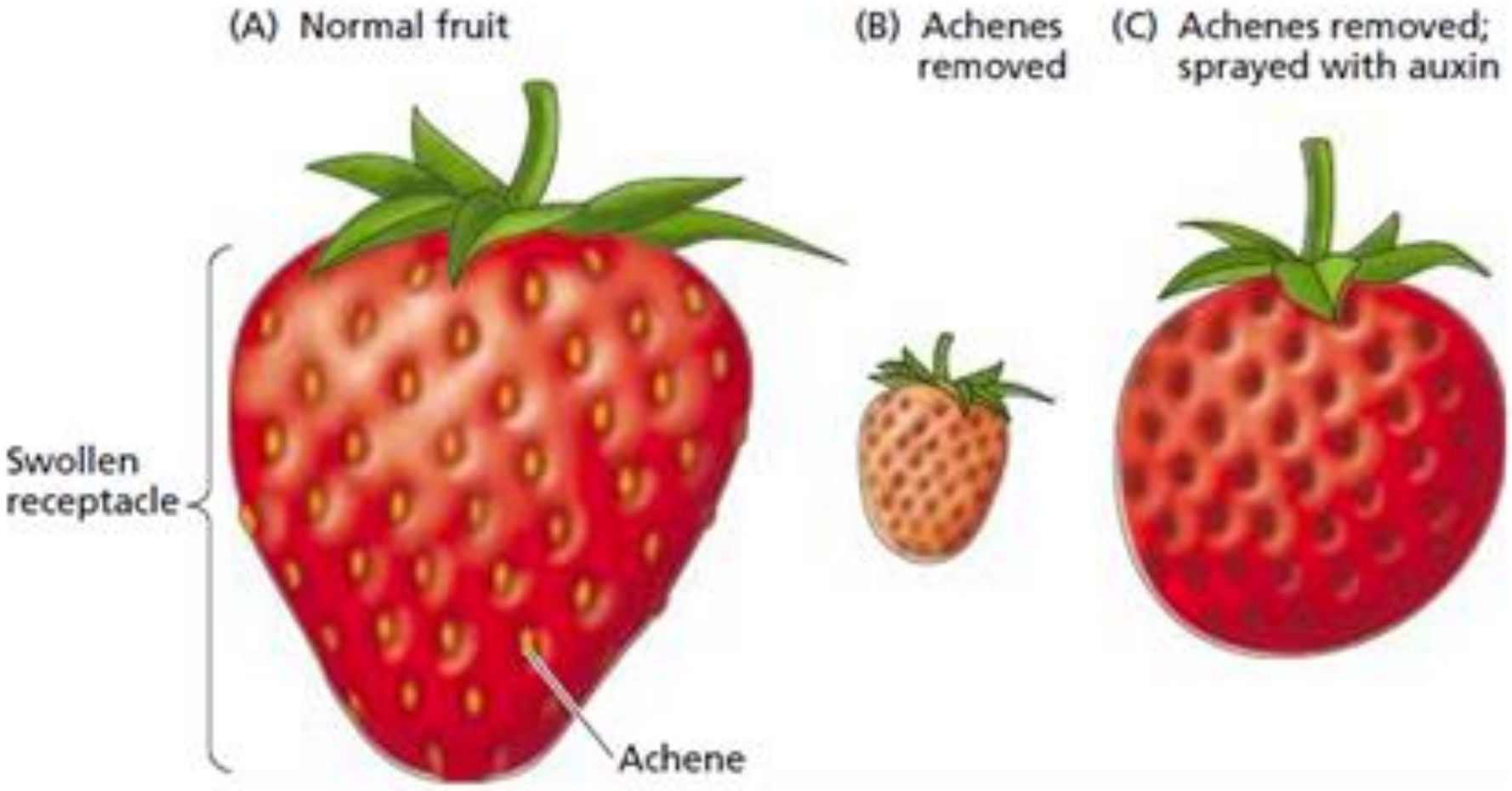
Scientific perspective on pruning:

Generally, when sink activity is decreased by removing active sinks or introducing nutrient deficiency, carbohydrates accumulate in leaves and photosynthesis becomes inhibited (Paul and Pellny, 2003)

Auxin acts as “fountain of youth”

- Auxin in main vine tip is moved to fruit sinks, promoting growth
- Auxin in main vine tip is moved to buds (read: rogue tertiaries), inhibiting their growth
- Auxin delays leaf aging
- Auxin in MVT signals demand for water/nutrient flow from root system
- Auxin promotes growth of adventitious roots

Auxin regulates fruit growth



So what about Auxin application?

–We’re a long ways off from using exogenous auxin to enhance fruit growth

For now, let microbes do the work

- Azospirillum brasilense bacterial inoculant
  - Secretes auxin, gibberellic acid, cytokinin
  - Fixes nitrogen
  - Enhances germination
  - Growth Promoter
  - Effects well substantiated by science

–Disclaimer: I am not paid or incentivized to endorse this product

Treatment showing significant adventitious rooting


Treat
Ctrl

A. Brasilense application resulted in 14% increase in dry root matter

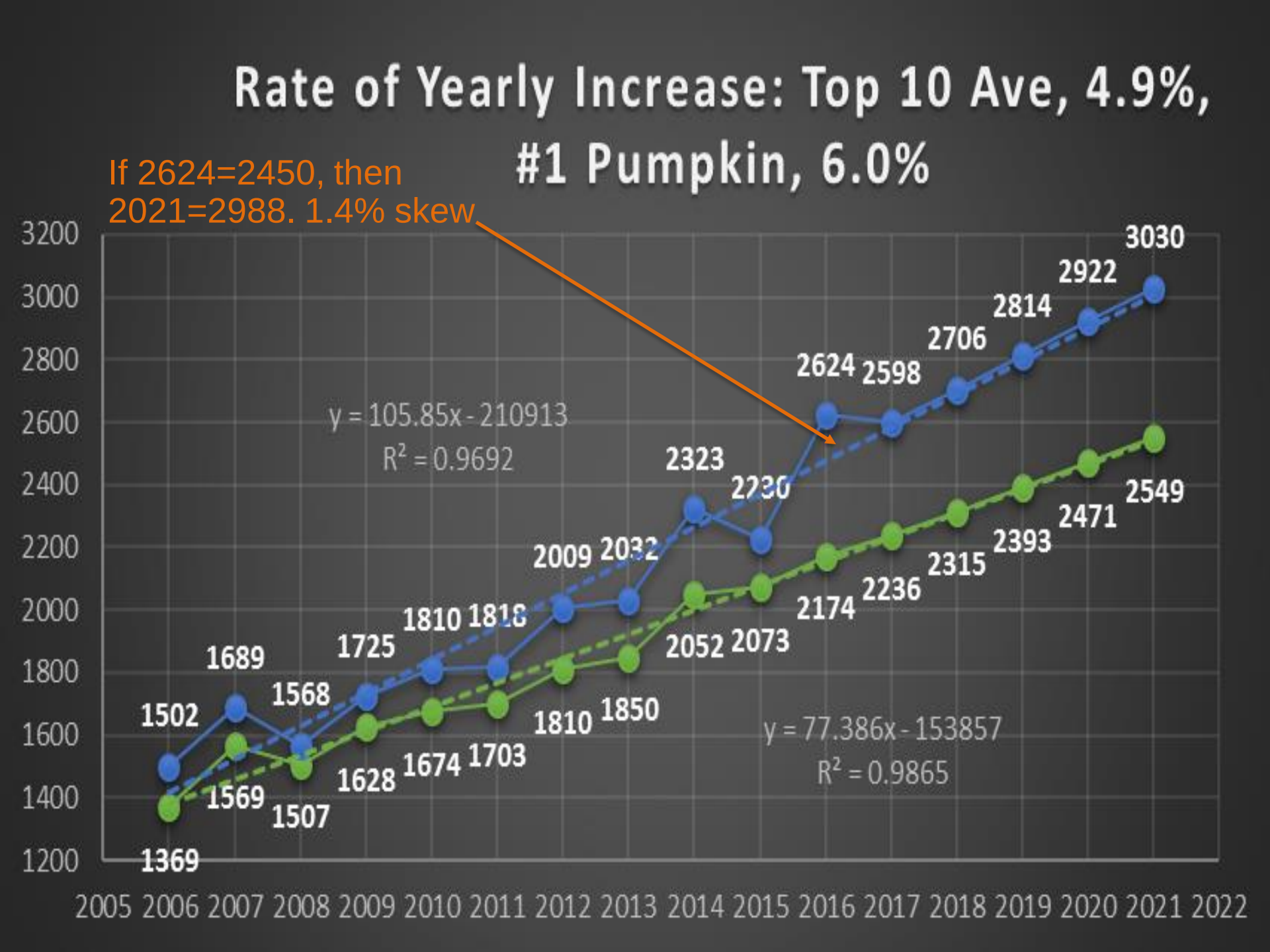
- Design: 32 seeds, 16 treatment & 16 control
- 2 week growth time
- Seed inoculated & two drench apps @ recommended rate
- Roots washed, dried, & weighed

A. brasilense Garden Tactics

- Inoculate seed prior to planting
- Drench apply @ crown ~2-3 weeks
- Include in trench mix and/or drench app

A. brasilense Garden Tactics (wild & crazy)

Micro-slit & apply to stimulate adventitious rooting


Rate of Yearly Increase: Top 10 Ave, 4.9%, #1 Pumpkin, 6.0%
If 2624=2450, then 2021=2988. 1.4% skew
y = 105.85x - 210913
R² = 0.9692
y = 77.386x - 153857
R² = 0.9865
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
1502
1689
1568
1725
1810
1818
2009
2032
2323
2230
2624
2598
2706
2814
2922
3030
1369
1569
1507
1628
1674
1703
1810
1850
2052
2073
2174
2236
2315
2393
2471
2549


1422 Ailts, 2010
Thank you!