Comparative Analysis of Pawpaw Production Data from 2005-2012

Based on the work of Laine Greenawalt, M.S.
from the records of Dr. Ron Powell, Fox Paw Ridge Farm

Presented by Robert G. Brannan, Ph.D.

North American Pawpaw Growers Association Annual Meeting
May 20, 2017
Wilmington College

OHIO UNIVERSITY
College of Health Sciences and Professions
Division of Food and Nutrition Sciences

But first, a shameless plug …
Pawpaw Research at Ohio University

1. Zhang, L. and Brannan R.G. The **Effects of High Pressure Processing**, Browning Additives, and Storage Period on Sensory Analysis, Color, and Polyphenol Oxidase Activity in Pawpaw (*Asimina Triloba*) Pulp.
2. Brannan, R.G., Peters, T., and Kukor, B. **Inhibition of Lipid Oxidation** of Pulp from Nine Pawpaw (*Asimina triloba*).
3. Brannan, R.G., Faik, A., Pattahil, S., Goelz, R. Identification and comprehensive **analysis of cell wall glycan epitopes** and polyphenol oxidase from two varieties of pawpaw (*Asimina triloba* [L.] Dunal) fruit pulp as affected by high pressure processing and refrigerated storage
4. Brannan, R.G. and Wong, G. 2017. **Effect of frozen storage** on polyphenol oxidase, antioxidant content, and color of pawpaw (*Asimina Triloba* [L.] Dunal) fruit pulp. Journal of Food Research. 6(3): 93-101.1.
5. Brannan, R.G. 2016. **Polyphenol Oxidase** in Pawpaw (*Asimina triloba* [L.] Dunal) Fruit Pulp from Different Varieties. Journal of Food Research. 5(1):33-39
6. Brannan, R.G., Peters, T., and Talcott, S.T. 2015. **Phytochemical analysis** of ten varieties of pawpaw (*Asimina triloba* [L.] Dunal) fruit pulp. Food Chemistry. 168: 656-661.
7. Brannan, R. G., Salabak, D. E., and Holben, D.E. 2012. **Sensory analysis of pawpaw** (*Asimina triloba*) pulp puree: Consumer appraisal and descriptive lexicon. Journal of Food Research. 1(1).
8. Brannan, R.G., Salabak, D. E. 2009. Ability of Methanolic **Seed Extracts of Pawpaw** (*Asimina triloba*) to Inhibit n-3 Fatty Acid Oxidation Initiated by Peroxyl Radicals and Reactive Oxygen, Nitrogen, and Sulfur. Food Chem. 114:253-258.
9. Harris, G.G. and Brannan, R.G. 2009. An Evaluation of **Antioxidant Compounds**, Reducing Potential, and Radical Scavenging of Pawpaw (*Asimina triloba*) Fruit Pulp from Different Stages of Ripeness. LWT: Food Science and Technology. 42:275–279.

Ongoing Research at OU

Activity	Outcome
Nutrient Content	In Progress? Goal is USDA Nutrient Database
Sensory Analysis (Taste, Flavor, Aroma)	Attributes in varieties with commercial potential (Sweet/Bitter Balance)
Antioxidant Capacity	Identify varieties with most effective antioxidants; create HEALTHY HALO
Cell Wall Components that Promote Post Harvest Tissue Softening	Glycome analysis used to identify compounds; Goal is strategy to produce firm, pulpy fruits.
Polyphenol Oxidase Activity (Browning enzyme)	Minimize browning after harvest
Shelf Life Extension	High Pressure Processing, Stevia, Ascorbic acid

Scientific Name:	*Asimina triloba*
Common Name:	North American Pawpaw (many others)
Category:	Dicot
Kingdom:	Plantae
Subkingdom:	Tracheobionta
Class:	Magnoliopsida
Order:	Magnoliales
Family:	Annonaceae
Genus:	Asimina
Species:	Triloba

Annonaceae Fruits

- *Annona squamosa*

  (Sugar Apple, Sweetsop, Custard Apple)

Annonaceae Fruits

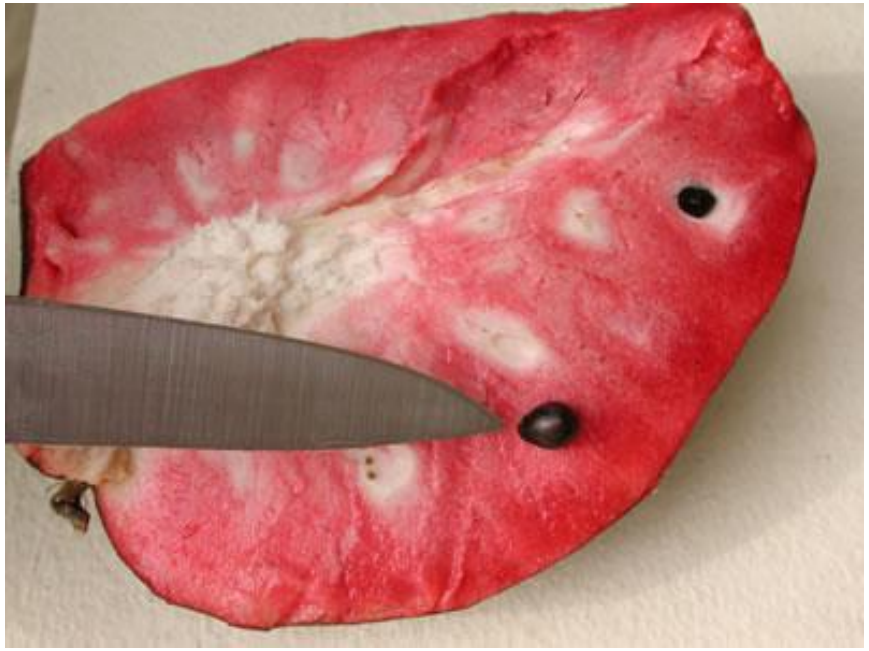
- Annona cherimola

  (Cherimoya, Custard Apple)

Annonaceae Fruits

- Atemoya (Cherimoya x Squamosa)

  (Red Sugar Apple, Pineapple Sugar Apple)



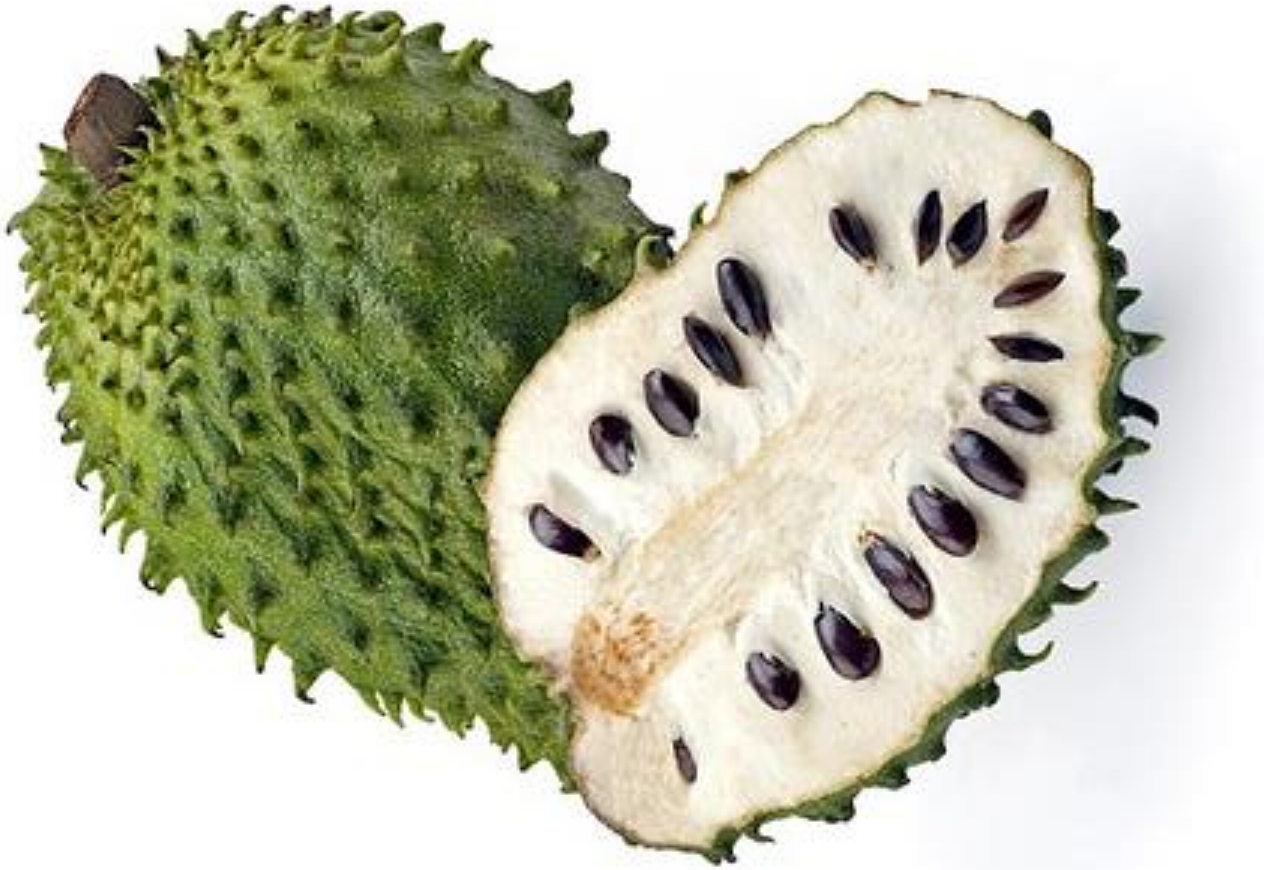
Annonaceae Fruits

- Annona reticulata

  (Custard Apple, Wild Sweetsop, Bull's Heart)

Annonaceae Fruits

- Annona muricata (Soursop, Graviola, Guanabana)



Annonaceae Fruits

- Asimina triloba (pawpaw)

What is unusual about the pawpaw?

North American Pawpaw is America's Native Tropical Fruit!

Longstanding Pawpaw Nutritional Info

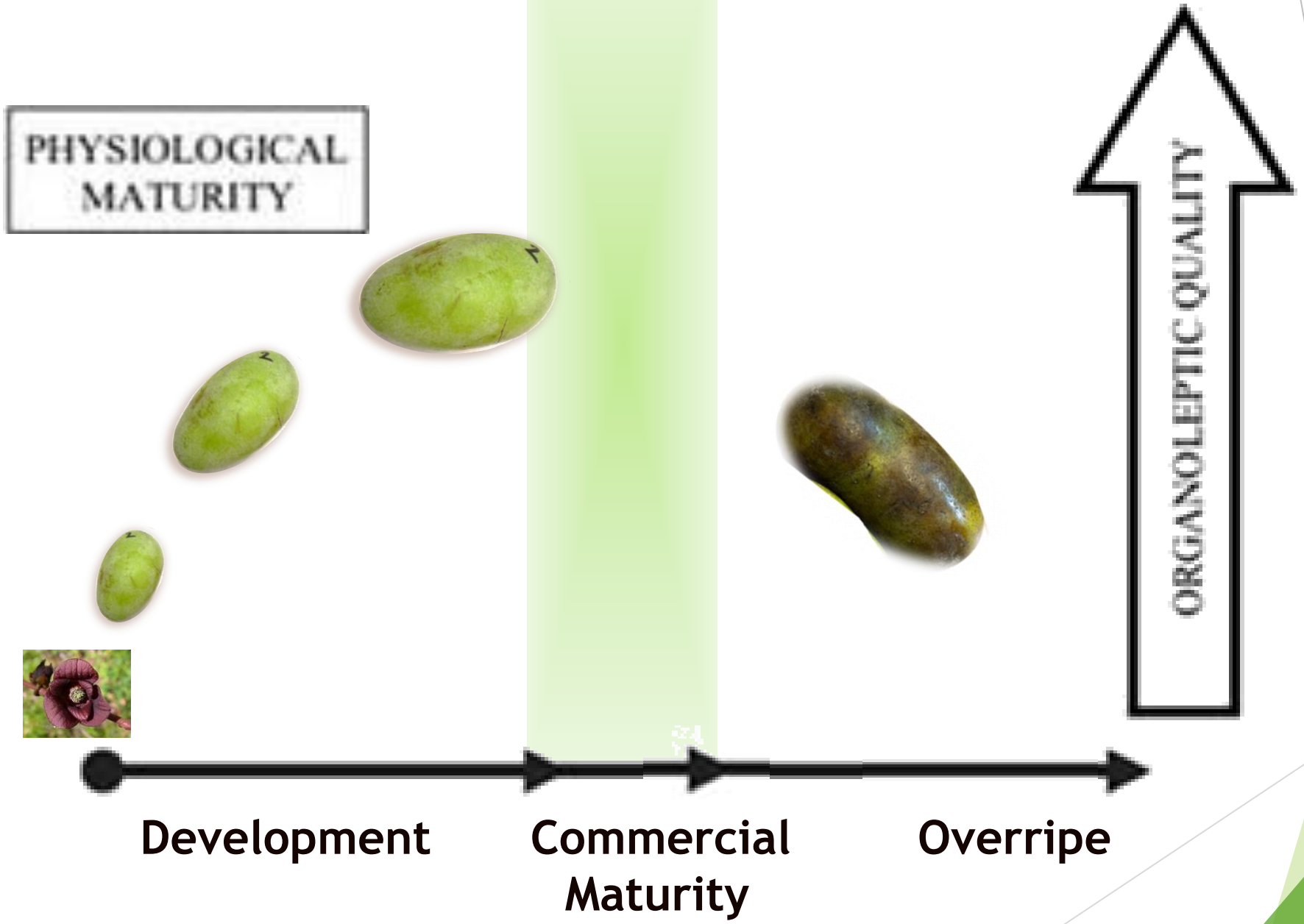
Composition						
Food Energy [b]						
Protein [b]					0.5	3.0
Total Fat [b]					1.3	4.2
Carbohydrate [b]					1.4	2.7
Dietary Fiber [b]					1.7	6.5
Vitamins						
Vitamin A [c]					0.6	**3.8**
Vitamin C [c]					1.1	5.6
Thiamin [c]					1.7	3.6
Riboflavin [c]					1.0	4.3
Niacin [c]					1.5	6.7
Minerals						
Potassium [b]						
Calcium [c]						
Phosphorus [c]	**5.9**	2.5	0.9	1.8		
Magnesium [c]	**35.9**	9.2	1.6	3.2		

Peterson, R.N., Cherry, J.P., and Simmons, J.G. 1982. Composition of Pawpaw (Asimina triloba) Fruit. Ann. Rpt. N. Nut Growers Assoc. 77:97-106.

What we actually know about pawpaw nutrition

- Moisture 72-77%
- Fat 0.5%
- Protein 1%
- Carbs (sugar) 10-25%
- Ash (minerals) ... 1%
- Vitamin C ..... 5 mg/100 g

  (compared to >30 for 1982 study
- pH 6.0-6.5


PHYSIOLOGICAL MATURITY
ORGANOLEPTIC QUALITY
Development
Commercial Maturity
Overripe

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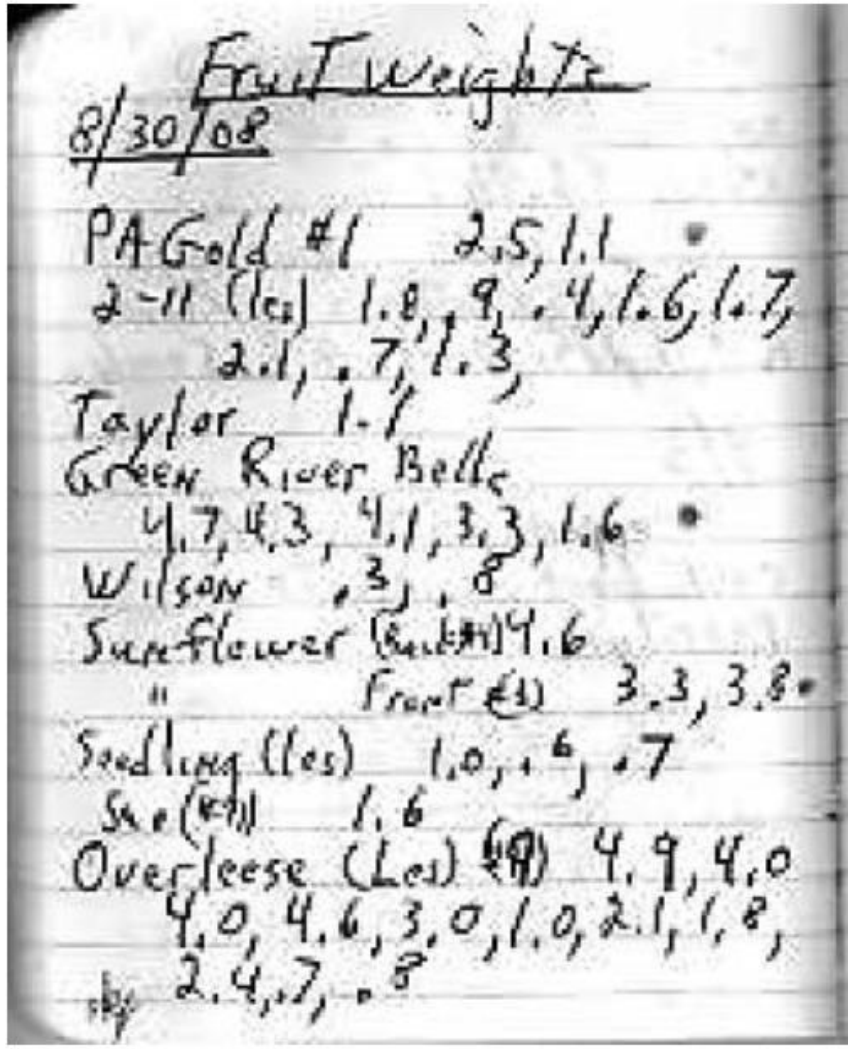
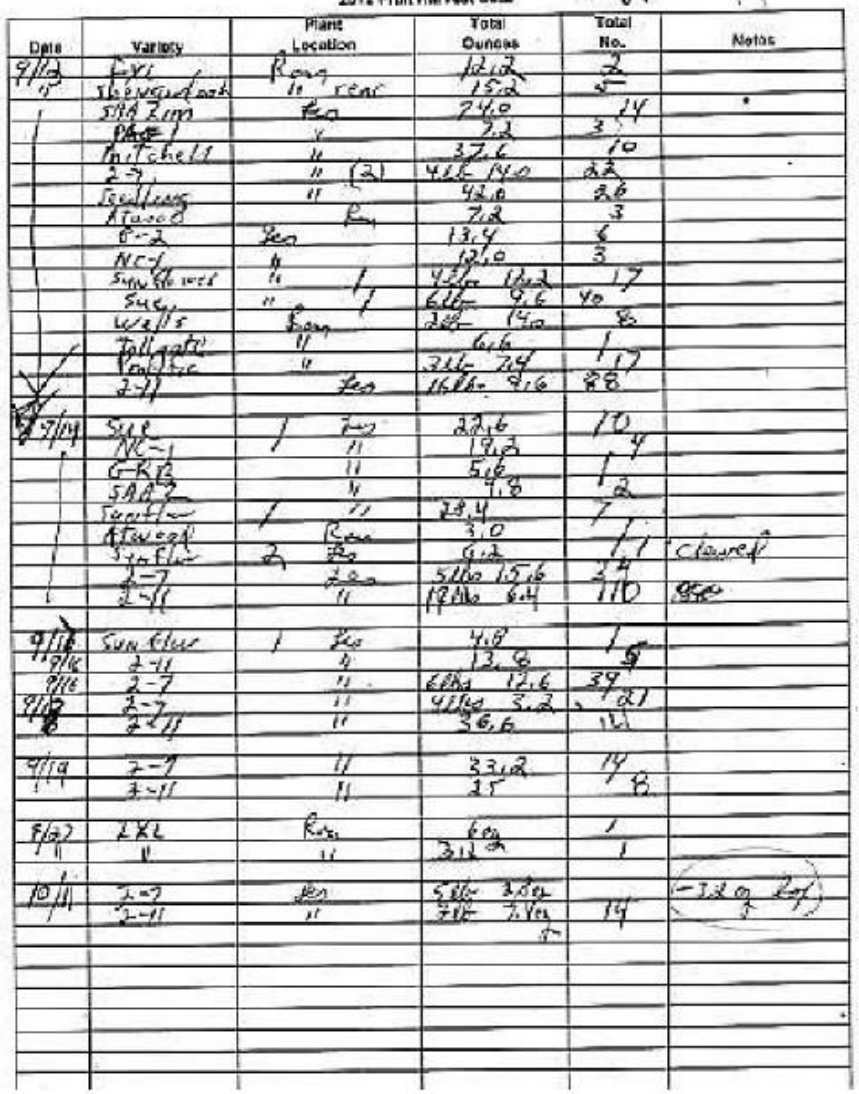
Handwritten Records



Fruit weights
8/30/08

PA Gold #1 2.5, 1.1
2-11 (Les) 1.8, 9, .4, 1.6, 1.7, 2.1, .7, 1.3,
Taylor 1.1
Green River Bell c
4.7, 4.3, 4.1, 3.3, 1.6
Wilson , 3, , 8
Sunflower (Back#1) 4.6
" Front (#1) 3.3, 3.8
Seedling (Les) 1.0, .6, .7
Sue (#1) 1.6
Overleese (Les) (#1) 4.9, 4.0
4.0, 4.6, 3.0, 1.0, 2.1, 1.8,
2.4, .7, .8



2012 Fruit Harvest Data

Date	Variety	Plant Location	Total Ounces	Total No.	Notes
9/13	Lexi	Row	12.2	2	
"	Sheringham	11 rear	15.2	5	
	SBA Zinn	Rear	24.0	14	
	Page	"	2.2	3	
	Mitchell	"	37.6	10	
	2-7	" (2)	4lb 14.0	22	
	Seedling	"	42.8	26	
	Atwood	Row	7.2	3	
	8-2	Rear	13.4	6	
	NC-1	"	12.0	3	
	Sunflower wild	" /	4lb 10.2	17	
	Sue	" /	6lb 9.6	40	
	Wells	Rear	2lb 14.0	8	
	Tollgate	"	6.6	1	
	Pacific	"	3lb 7.4	17	
	2-11	Rear	16lb. 9.6	88	
9/14	Sue	/ Row	22.6	10	
	NC-1	"	19.2	4	
	GRB	"	5.6	1	
	SBA Zinn	"	4.8	2	
	Seattle	/ "	28.4	7	
	Atwood	Row	3.0	1	
	Sunflow	2 Rear	Gib	1	Chewed
	2-7	2nd	5lbs 15.6	24	
	2-11	"	19lbs 6.4	110	950
9/15	Sun Flow	1 Rear	4.8	1	
9/16	2-11	"	13.6	5	
9/16	2-7	"	6lbs 12.6	39	
9/18	2-7	"	4lbs 3.2	21	
	2-11	"	36.6	14	
9/19	2-7	"	33.2	14	
	2-11	"	35	8	
9/27	LXL	Row	6oz	1	
"	"	"	3.2 oz	1	
10/11	2-7	Rear	5lb 3.0z		-32 oz Ref
	2-11	"	7lb 7.4oz	14	

Methods - *Plantings*

- Plantings
  - 2003-2006
  - 2 locations
    - Butler County
    - Adams County

Methods - *Fruit Collection*

- Fruit collection
  - Only “dropped” fruit
  - AM & PM
- Data recorded
  - Variety
  - Tree location
  - Date of collection
  - Total number of fruit
  - Total fruit weight

Methods - *Statistical Analysis*

- 3 data categories
  - All 52 varieties
    - Varieties in a genetic group
    - Varieties not in a genetic group

Genetic Groups
Taylor & Wilson (2)
Susquehanna (5)
Wabash (5)
Wells (3)
Overleese (9)

Pomper, K. W., Lowe, J. D., Lu, L., Crabtree, S. B., Dutta, S., Schneider, K., & Tidwell, J. (2010). Characterization and identification of pawpaw cultivars and advanced selections by simple sequence repeat markers. *Journal of American Society for Horticultural Science, 135*(2), 143-149.

Genetic Grouping of Pawpaw Varieties

Group	Varieties included in current study	Varieties not included in current study
Taylor and Wilson	Taylor, Wilson	None
Susquehanna	Zimmerman, PA Golden 1 and 3, Prolific, Susquehanna	8-20, 2-10, 2-54, 11-13, 3-11
Wabash	Sweet Alice, Greenriver Belle, Potomac, Rappahannock, PA Golden 4	Wabash, 9-58, 10-35, 9-47, Cales Creek
Wells	Wells, Sue, Middletown	M. Gordon, 3-21, 7-90, BH-10, 5-5
Overleese	Sunflower, Shenandoah, Davis, Overleese, IXL, Taytwo, Mitchell, NC-1, Rebecca's Gold	1-68, 1-23

Note. Data from "Characterization and Identification of Pawpaw Cultivars and Advanced Selections by Simple Sequence Repeat Markers," by K. W. Pomper, J. D. Lowe, L. Lu, S. B. Crabtree, S. Dutta, K. Schneider, and J. Tidwell, 2010, *Journal of American Society for Horticultural Science*, *135*(2), p. 146.

Table 4. Allelic fingerprints of five microsatellite loci for the 28 pawpaw cultivars and 13 advanced selections.

Genotype	Allele size (bp) for each locus				
	Pp-B3	Pp-B103	Pp-B129	Pp-C104	Pp-G119
10–35	183/191	266/339	166/172	184	158/164
11–13	191	264/305	166/172	184	158
1–23	185/189	290/310	158	184	158/176
1–68	185/187	268/341	158/179	175/184	158/164
2–10	191	264/270	170/172	184	161/164
2–54	191	264/270	162/166	184	161
3–11	191	272/288	158/172	184	158/161
3–21	189/191	266/305	166/170	184	161/164
5–5	183/189	270/305	166/168	184	161
7–90	185/191	305/342	170/176	184	161/164
8–20	189/191	264/270	162	184	158/167
9–47	183	272/274	158/166	184	158/161
9–58	183/191	264/339	170/176	184	158/164
'BH10'	189	319/321	162/170	184	144/161
'Cales Creek'	175/183	266/274	156/158	184	158/164
'Davis'	185/189	264/268	158/164	175/184	158/164
'Greenriver Belle'	183/189	264/266	162/172	184	158/161
'IXL'	187/189	274/309	158/162	175/184	158/164
'M. Gordon'	185/195	270/312	164/170	184	161/164
'Middletown'	183/193	270/321	170	184	158/161
'Mitchell'	–/–	266/321	158/172	184	158/167
'NC-1'	185/193	266	158/162	184	158/161
'Overleese'	185/189	264	158/164	175/184	158
'PA-Golden#1'	191/193	336/343	172/176	184	158/164
'PA-Golden#3'	189/191	336/343	158/172	184	161/170
'PA-Golden#4'	175/183	319/326	164	184	158/161
'Potomac'	183/191	264/324	170	184	158/164
'Prolific'	189/191	309/323	158/162	184	158
'Rappahannock'	183/191	266	166	184	164/170
'Rebecca's Gold'	185/193	266	158/162	184	158/161
'Shenandoah'	185/187	264/274	162/164	184	158/164
'Sue'	175/189	266/329	166/180	184	161/164
'Sunflower'	187	274/341	162/180	175/184	164
'Susquehanna'	189/191	264/270	162	184	158/167
'Sweet Alice'	175/183	260/324	166/182	184	144/164
'Taylor'	183/185	268/322	173/193	184	167/170
'Taytwo'	175/185	252/290	158	184	164/176
'Wabash'	183	266/324	170/172	184	158/170
'Wells'	175/191	276/290	177	184	161/164
'Wilson'	183/185	268/321	173/193	184	167/170
'Zimmerman'	191/195	303/324	164/177	184	158

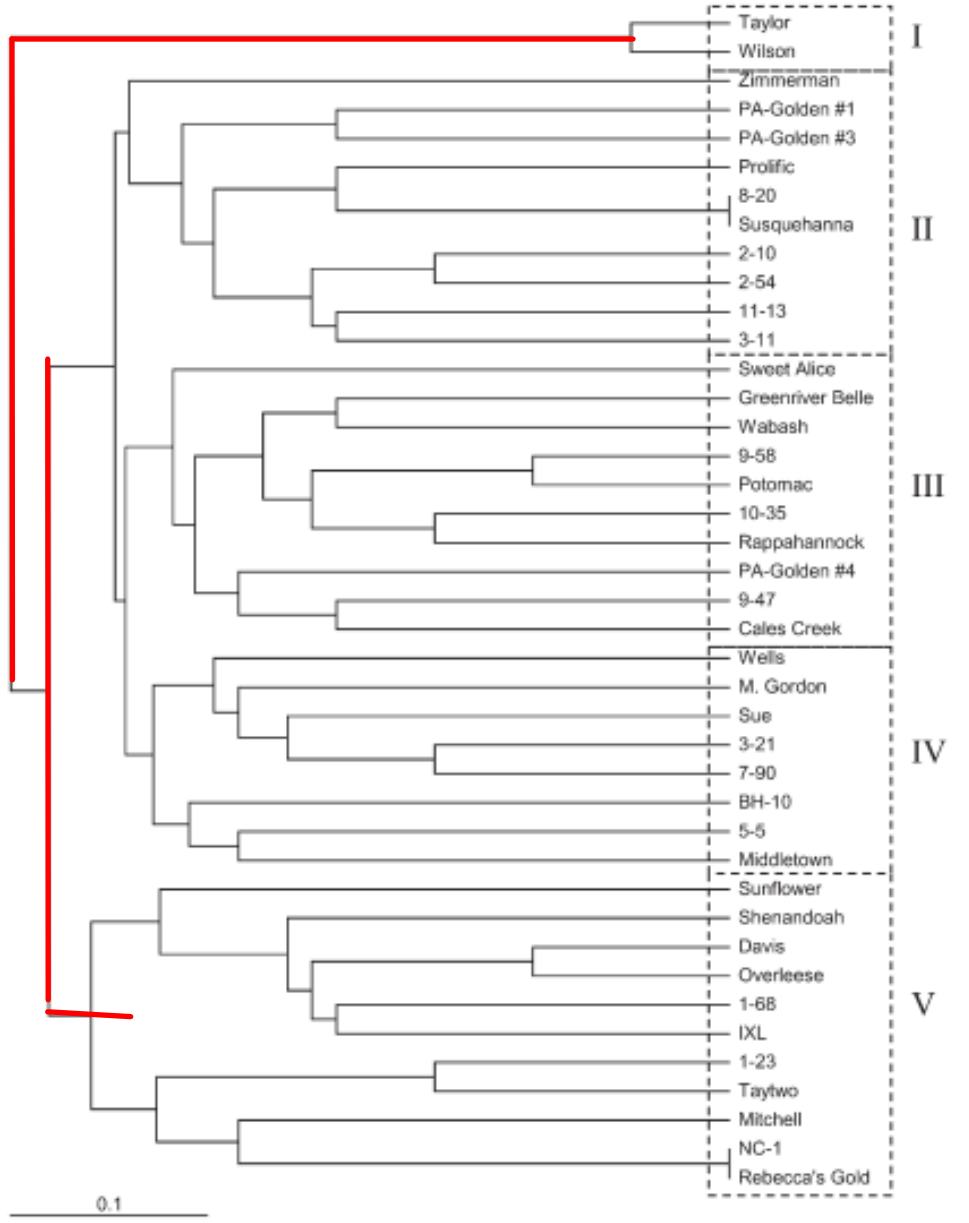


Fig. 1. UPGMA dendrogram of 41 pawpaw genotypes based on five microsatellite loci and shared allele distance. Genotypes are grouped by 'Taylor' and 'Wilson' (Group I), 'Susquehanna' (Group II), 'Wabash' (Group III), 'Wells' (Group IV), and 'Overleese' (Group V).

Results - *Harvest Ranges by Year*

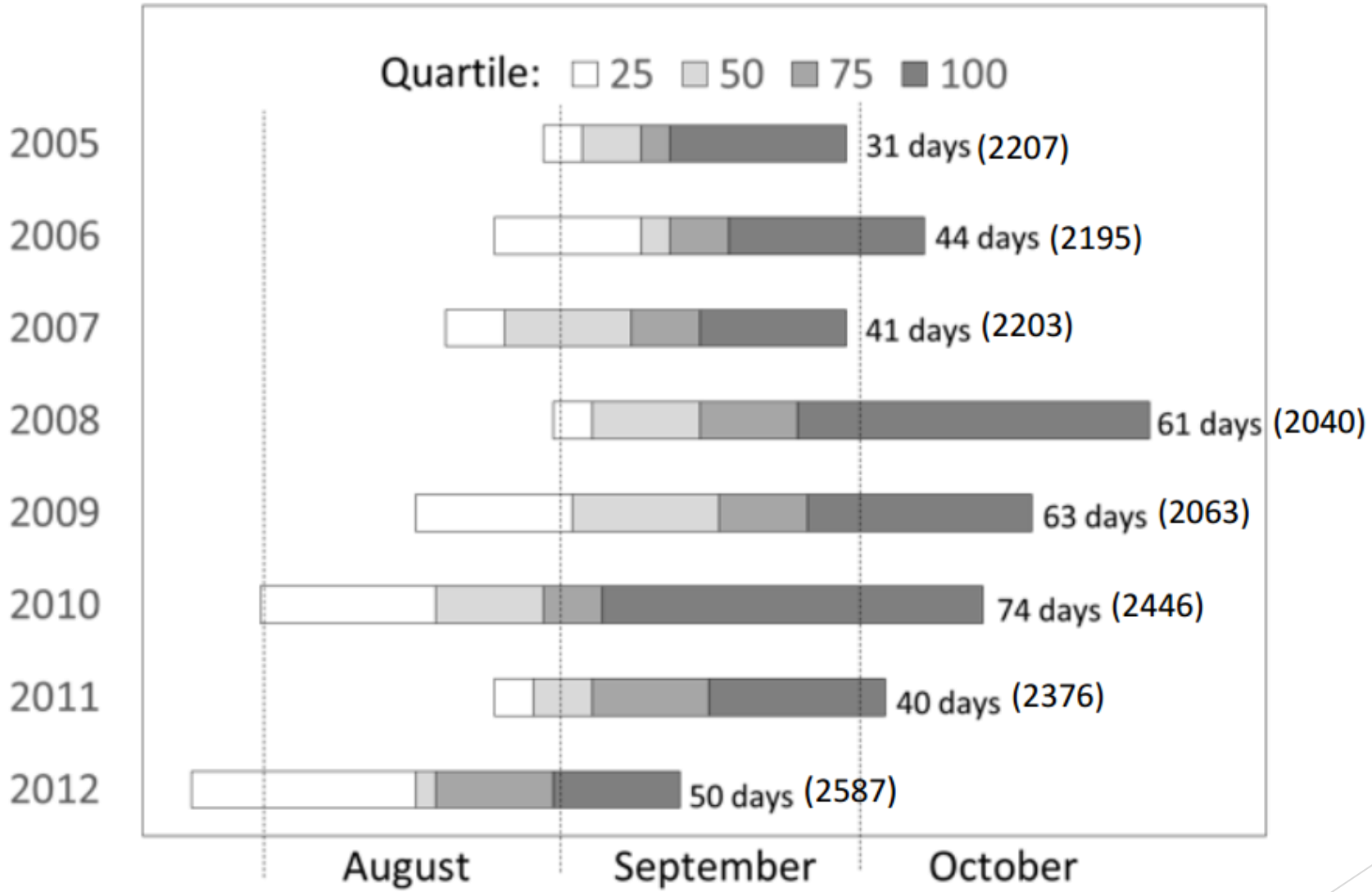


Figure 7. Pawpaw harvest date ranges (from first to last record) divided into quartiles for each year for all varieties and locations. (page 48)

Growing degree days (GDD)

- Plants grow in a cumulative stepwise manner, strongly influenced by the ambient temperature. Growing degree days take aspects of local weather into account and allow gardeners to predict the plants' pace toward maturity.
- GDD measure of heat accumulation used by horticulturists, gardeners, and farmers to predict plant and animal development rates such as
  - the date that a flower will bloom
  - an insect will emerge from dormancy
  - a crop will reach maturity.
- GDD can be used to:
  - assess the suitability of a region for production of a particular crop;
  - estimate the growth-stages of crops, weeds or even life stages of insects;
  - predict maturity and cutting dates of forage crops;
  - predict best timing of fertilizer or pesticide application;
  - estimate the heat stress on crops;
  - plan spacing of planting dates to produce separate harvest dates.

Phenological Sequence for Secrest Arboretum

Species	Event	Degree-Days
Red Maple	first bloom	45
Eastern Tent Caterpillar	egg hatch	92
Eastern Redbud	first bloom	197
Gypsy Moth	egg hatch	203
Snowdrift Crabapple	first bloom	214
Birch Leafminer	adult emergence	231
Common Lilac	first bloom	238
Pine Needle Scale	egg hatch	301
Vanhoutte Spirea	first bloom	309
Lilac Borer	adult emergence	336
Black Cherry	first bloom	376
Euonymus Scale	egg hatch	463
Black Locust	first bloom	503
Bronze Birch Borer	adult emergence	519
Mountain-laurel	first bloom	565
Juniper Scale	egg hatch	579
Littleleaf Linden	first bloom	878
Japanese Beetle	adult emergence	966

From:
Biological Calendars:
Using Degree-Days and Plant Phenology to Predict Pest Activity

By Dan Herms

Department of Entomology
The Ohio State University
Ohio Agricultural Research and Development Center
Wooster
herms.2@osu.edu

Results - *Harvest Ranges by Year*

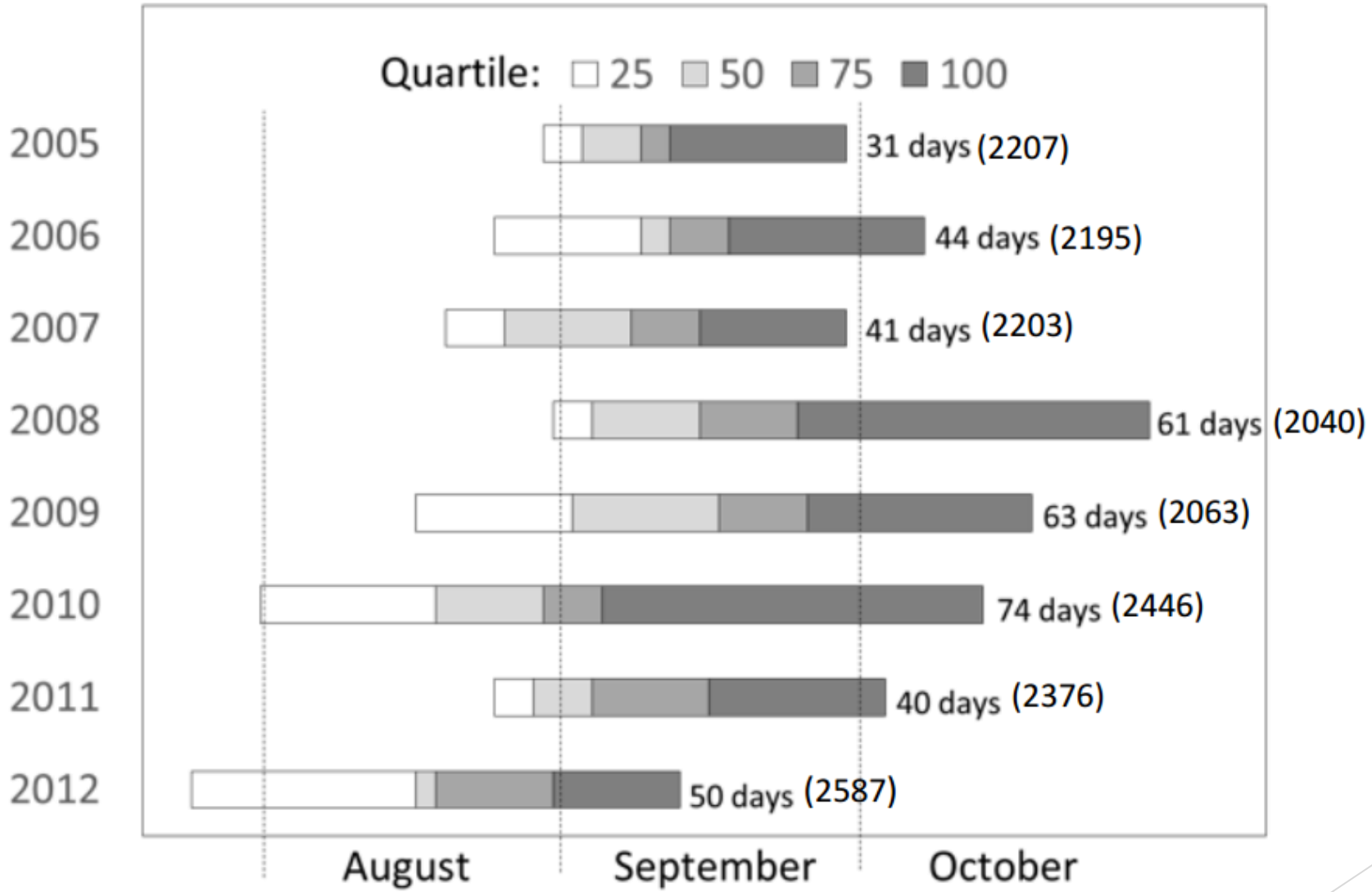
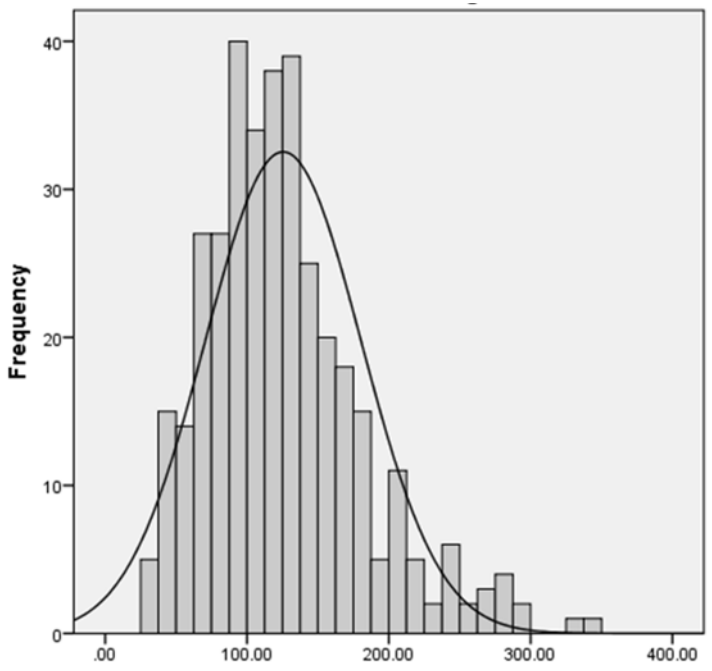


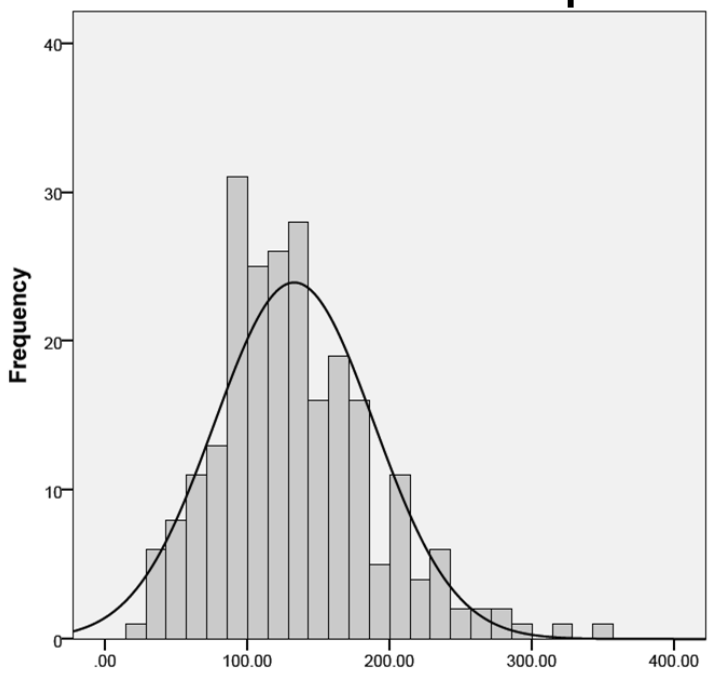
Figure 7. Pawpaw harvest date ranges (from first to last record) divided into quartiles for each year for all varieties and locations. (page 48)

Results - *Fruit Weight f Analysis*

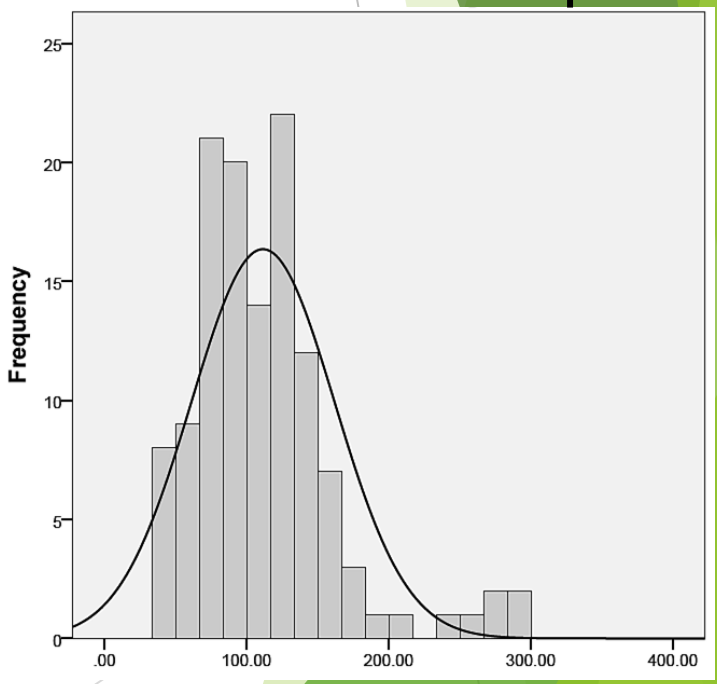
All 52 Varieties



Varieties in a Genetic Group



Varieties Not in a Genetic Group



Results - *Average Fruit Weight, Yield, and Harvest Length for 3 Datasets*

Subset of data (# of varieties)	Number of trees	Average fruit weight (g)	Yield (g)	Harvest length (days)
All Varieties (52)	359	125 ± 55	5317 ± 7565	16 ± 13
Uncategorized (28)	124	111 ± 50	3842 ± 6099	16 ± 14
All Genetic groups (24)	235	132 ± 55	6096 ± 8139	17 ± 12

Results - *Average Fruit Weight, Yield, and Harvest Length for each Genetic Group*

Genetic group (# of varieties)	Number of trees	Average fruit weight (g)	Yield (g)	Harvest length (days)
	24	$92^{d} \pm 39$	$3747^{b} \pm 4509$	$16^{ab} \pm 11$
Zimmerman, PA Golden 1 and 3, Prolific, Susquehanna	30	$137^{ab} \pm 62$	$7851^{a} \pm 10144$	$19^{a} \pm 12$
	30	$98^{cd} \pm 36$	$3570^{b} \pm 6000$	$13^{b} \pm 13$
Wells, Sue, Middletown	30	$112^{bc} \pm 48$	$7449^{a} \pm 9634$	$16^{ab} \pm 14$
Sunflower, Shenandoah, Davis, Overleese, IXL, Taytwo, Mitchell, NC-1, Rebecca's Gold	119	$155^{a} \pm 53$	$6517^{ab} \pm 8158$	$19^{a} \pm 13$

Note. Means within the genetic groups with different superscripts are significantly different at $p < 0.05$

Top Ten (and Bottom Ten) Individual Varieties

Variety	Weight	Variety	Yield	Variety	Harvest Days
Davis	244	SAA Zimmerman	18182	KYSU 2-11	33
Mango	210	KSU Atwood	11349	Green River Belle	26
SAB Overleese	208	PA Golden 1	11161	Sunflower	25
Susquehanna	194	Sunflower	10998	SAA	24
NC-1	172	Green River Belle	10818	KYSU	24
SAA Zimmerman	170	Sue	10215	PA	23
Rebecca's Gold	167	Rebecca's Gold	9953	KSU	22
Overleese	160	NC-1	9550	IXL	22
SAA Overleese	156	KYSU 2-11	8335	KYSU	22
Cawood & Shenandoah	153	Overleese	7208	Cawood	22
	(125)		(5317)		(16)
Ruby Keenan	79	PA Golden 4	542	Rana	5
SunGlo	79	Broad	483	Davis	3
Shawnee Trail	77	SAA Overleese	472	Potomac	3
Kirsten	76	Potomac	427	Convis	2
Wild	76	Ruby Keenan	359	Kirsten	2
Convis	74	Kirsten	337	SAB Overleese	1
Rana	73	Rana	281	Lady D	1
Rappahannock	72	PA Golden 3	276	Cullaman Late	1
LA Native	68	Wild	264	SAA Overleese	1
Cullaman Late	10	Shawnee	99	Shawnee	1

Results - *Average Fruit Weight, Yield, and Harvest Length, by Year, for 52 Pawpaw Varieties*

Year	N	Average fruit weight (g)	Yield (g)	Harvest length (days)
2005	11	$121^{abc} \pm 43$	$679^{d} \pm 564$	$5^{d} \pm 6$
2006	30	$152^{a} \pm 48$	$4134^{bcd} \pm 6770$	$13^{bcd} \pm 11$
2007	7	$101^{c} \pm 47$	$1254^{cd} \pm 1008$	$9^{cd} \pm 6$
2008	38	$100^{c} \pm 46$	$5289^{abcd} \pm 4837$	$21^{ab} \pm 15$
2009	38	$138^{ab} \pm 54$	$9145^{a} \pm 9087$	$25^{a} \pm 13$
2010	86	$143^{a} \pm 61$	$3013^{bcd} \pm 5045$	$16^{bc} \pm 13$
2011	75	$122^{abc} \pm 55$	$6027^{abc} \pm 8560$	$17^{bc} \pm 11$
2012	74	$108^{bc} \pm 47$	$6881^{ab} \pm 9080$	$16^{bc} \pm 13$

Note. Means within columns with different superscripts are significantly different at $p < 0.05$.

Results – *Average Fruit Weight, Yield, and Harvest Length, by Year, for 52 Pawpaw Varieties*

- No difference in average fruit weight by location.
- Difference in Yield by location:
  - Butler County #2 > Butler County #1 > Adams County
- Difference in Harvest Days by Location:
  - Butler County #2 > Butler County #1 > Adams County

Average Fruit Weight Negatively Correlated with Total Number of Fruit

Treatment	Fruit weight (g)[z]	No. of fruit/tree	No. of clusters/tree
Unthinned	88	129	62
Thinned	129	86	86
P-value	0.0048*	0.0518	0.3235

Average Fruit Weight (g) per Tree

From Crabtree, Pomper, and Lowe (2010) 64(4): 234-240 2010

Is Genetic Group Important? (Average Fruit Weight)

Group	Avg Fruit Weight	Yield	Harvest Days
Taylor $ Wilson	91	3746	15
Wabash	95	3675	12
Uncategorized	111	3842	16
Wells	115	7923	16
Susquehanna	134	9020	18
Overleese	154	6676	18

Conclusions

- Average Fruit Weight is “Normally Distributed.”
  - The frequency of finding “big ones” and “small ones” is the similar for each variety.
- Harvest Days
  - 2005 – shortest, 2010 – longest , 2008 – started late, ended late, 2012 – started early, ended early
  - 2 years with notable weather -
  - 2007 – drought; 2010 –Hurricane Ike
- Location
  - No difference in average fruit weight by location
  - Yield and harvest length did differ among locations
- Year
  - Average fruit size largest in 2006 & 2010)
  - Yields also varied widely between years with the largest being 2009 and the smallest 2005.
- Genetic Groups:
  - Overleese had larger fruit weight than the groups Taylor and Wilson, Wabash, and Wells.
  - Susquehanna and Wells had the largest yields.
  - No apparent advantage to being in a genetic group

An Important Finding:

- Number of Fruit is inversely proportional to average fruit weight
- Pomper recommends thinning.

Bottom Line:
The Top Ten and the Bottom Ten

Top 10

- SAA Zimmerman
- NC-1
- Rebecca's Gold
- Sunflower
- Overleese
- Wells
- Shenandoah
- Mango
- David

Bottom 10

- Rana
- Wild
- Shawnee
- Cullaman Late
- Kirsten
- Ruby
- La Native
- PA Golden 3
- Convis
- Rappahannock

I’m looking for judges for
Best Pawpaw Contest
Pawpaw Cookoff