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A Retrospective Analysis of Pawpaw *(Asimina triloba [L.] Dunal)* Production Data from 2005-2012[1]

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Abstract

This study examined 52 cultivars of pawpaw *(Asimina triloba)* grown at three locations in southwestern Ohio, of which 24 fit into previously identified genetic groups based on simple sequence repeat markers, harvested from 2005-2012. The harvest duration ranged from 31 days in 2005 to 74 days in 2010, and most of the fruit was harvested in Sept. A frequency analysis of average FW conducted for all cultivars revealed that average FW was normally distributed. The average FW ranged from 10 g ('Cullman Late') to 244 g ('Davis'), but of the more prolific cultivars the average FW ranged from 72 g ('Rappahannock') to 172 g ('NC-1'). Average FW and total number of fruit collected were negatively correlated (r = -0.21, $p < 0.001$). FW was not affected by location. Genetically similar cultivars were compared based on previously identified groupings. Cultivars assigned to the *Susquehanna* and *Overleese* genetic groups had significantly higher average FW and harvest length than other genetic groups. Results of this study expand research on pawpaw production and allow growers to select cultivars with market potential based on factors such as fruit size, yield, and harvest duration.

The pawpaw *(Asimina triloba)* is the largest fruit native to North America. It has a vast native growing range that spans 26 states corresponding to U.S. Department of Agriculture (USDA) plant hardiness zones 5-8 (Galli et al., 2007). The family Annonaceae, to which pawpaw belongs, contains over 2,400 species, all of which are tropical or subtropical except for pawpaw, making the temperate-growing fruit unique. Moreover, pawpaw trees are exclusive in that they are the only species of the 10 in the genus *Asimina* to produce a commercially viable fruit.

Pawpaw trees are shrub-like, understory trees that can grow up to 12 meters tall. They have long membranous leaves and maroon flowers that produce clusters of up to nine fruit in late summer to early fall (Geneve et al., 2003; Pomper and Layne, 2005). However, pawpaw flowers are likely self-unfruitful, making pollination an important factor that could limit commercial possibilities (Layne, 1996; Willson and Schemske, 1980). In addition, the normal bloom period of pawpaw flowers can last up to 4 weeks, resulting in an elongated harvest period in the fall which requires more labor and time intensive harvesting techniques (Pomper et al., 2008a).

In the early 1900s, the pawpaw was considered for increased commercialization efforts as a native, North American cash crop, but these efforts did not materialize (Pomper and Layne, 2005). Over the next 60 years, over four dozen pawpaw cultivars were named. However, because of neglect or abandonment only a few of these remain, which potentially could have eroded the genetic base of current pawpaw cultivars. Since then, breeders and hobbyists have increased efforts to domesticate the pawpaw. One result of this effort has been the establishment of the official *Asimina* satellite repository of the USDA National Clonal Germplasm Repository (Corvallis, OR) at Kentucky State University and the development of the Pawpaw Regional Variety Trial (Pomper et al., 2008b;

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Pomper et al., 2003b). In addition, attempts have been made to evaluate the genetic diversity in the pawpaw. Although an early study suggested that genetic diversity in the pawpaw was low (Rogstad et al., 1991), sampling techniques with greater discrimination showed that pawpaw has moderate to high genetic diversity and is similar to other temperate woody perennials (Pomper et al., 2003a; Pomper et al., 2010).

In 2000, the Ohio Pawpaw Growers Association (OPGA) was formed and ultimately became the first state chapter of the North American Pawpaw Growers Association (NAPGA). Currently, there are many cultivars with wide differences in fruit size, yield and other characteristics, but there are scant data on cultivars outside the Pawpaw Regional Variety Trial. Research has yet to determine which cultivars of pawpaw would be best for commercial purposes.

The objective of this research was to perform a retrospective analysis of pawpaw fruit production data collected from three sites over a period of eight growing seasons.

Materials and Methods

Plantings. Pawpaw fruit was harvested at three locations in southwest Ohio, namely a farm in rural Adams County (38.655517, -83.698615) that consists of three plots that total 1.0 ha and two discontinuous but adjacent plots in suburban Butler County (39.294718, -84.365151 and 39.294162, -84.364819) that are approximately 0.05 ha each. Trees were grafted onto seedling rootstocks that were at least two years old. Seedlings were grown by R. Powell from the collection at Kentucky State University that has served as the USDA National Clonal Germplasm Repository since 1994. The plants were grafted in late spring to early summer. The newly grafted plants were held for a year at one of the suburban locations before being planted at the orchard sites. The number of trees per cultivar ranged from 1 to 34 and the same cultivar was usually not planted at more than one location.

The plantings at the Butler County locations began in 2001 and tree site and cultivar selection was primarily random. The Adams County location, Fox Paw Ridge Farm, is a plot that contained pawpaw trees planted from 2003-2006. Fox Paw Ridge Farm plantings were organized in three sections. At the time of data collection, the 0.61-ha north section contained over 200 trees in east-to-west rows with 2.5 m between trees. The 0.2-ha east section contained four rows running north-south with trees 2.5 m apart. The 0.2-ha west section contained nine rows running north-south with 3 m between trees. In all three sections, rows were planted 4.5 m apart and cultivar selection was primarily random. There is notable soil variation between the Butler and Adams County locations. Soil at the Butler County locations is fine and loamy with good drainage (ideal for pawpaw growth) while soil at the Fox Paw Ridge Farm location is heavy clay (less ideal for pawpaw growth). The pawpaw trees were fertilized three times per season using 10-10-10 fertilizer. Rain water and cisterns were used to water the trees at the rural location, and the suburban locations were watered as needed using municipal water. The pawpaw trees were pruned and limbed as needed, however, the lower branches were retained to prevent deer rubbing. No pesticides were applied. The ground around the pawpaw trees was mowed and trimmed to control grass and weeds.

Growing degree days (GDDs) were calculated using a base temperature of 10°C according to previous research for pawpaw (Pomper et al., 2010). The Ornamental/Horticultural Insect Degree Day Calculator/Forecaster (http://weather.uky.edu/php/generic_dd_www.php) from the University of Kentucky Agricultural Weather Center was used to calculate temperature data for each harvest year from 1 Jan. to 1 Aug.

Data collection. Fruit were hand-collected and data were recorded in notebooks taken from spring 2005 through fall 2012. Fruit were collected each morning and evening,

and only fruit that had fallen from the tree was collected. Individual fruits were not weighed; rather, fruits from each tree were pooled and weighed in a batch using a CenTech Digital Scale (Harbor Freight Tools), recorded in ounces, and later converted into grams. Data collected for individual trees included cultivar, tree location, date of collection, total number of fruit collected, and total average FW. Two harvest variables were calculated. The variable "harvest days" is the number of days that fruit from a cultivar was harvested, whereas the variable "harvest duration" is calculated as the number of days each year from the first day a cultivar was harvested until the last day a cultivar was harvested.

Statistical analyses. The data were transcribed from paper to an electronic format by at least two investigators. Independent variables were identified as cultivar, harvest year, and tree location. Dependent variables were identified as harvest dates, total number of fruit collected per tree, total average FW, and average FW.

Data were analyzed using statistical analysis software SPSS Statistics 22 (IBM Corporation, Armonk, New York). Of the 60 cultivars for which there were data, 24 cultivars were placed into one of five genetic groups based on findings by Pomper et al. (2010), which used polymorphic microsatellite marker loci to identify genetically similar pawpaw cultivars. This created an independent variable of genetic group with five levels (Taylor & Wilson, Susquehanna, Wabash, Wells, Overleese). Genetic information was not available for 36 cultivars so these cultivars were not placed into a genetic group. Eight of these cultivars ('PA Golden 2', 'Allegheny', 'Forest Keeling', 'Vicky Russel', 'Pickle', 'Danica', 'Pepper', 'Cherokee Ridge') were excluded from data analysis because fruit collection only occurred once.

Multivariate ANOVAs were used to determine differences in average FW (g), yield (g), and harvest days between genetic groups, location, and year. If significance was noted at $p < 0.05$, Duncan's Multiple Range Test was used to separate means. Pearson product-moment correlation coefficient (r) was used to measure the relationship between average FW (g), total number of fruit produced per tree, tree yield (g), and harvest days. Significance for all analyses was set at $p < 0.05$.

Results and Discussion

Harvest data for all cultivars and years. The overall harvest duration, measured as the first collection day to the last collection day per year for all trees on all sites is shown in Figure 1. The harvest duration ranged from 31 days in 2005 to 74 days in 2010. Most of the fruit were harvested in Sept. Almost all individual trees had a first-recorded harvest date in Aug. or Sept. (64% and 35%, respectively) with the remaining 1% with a first-recorded harvest date in either July or Oct. The midpoint of harvest duration in terms of number of fruit migrated from mid-Sept. from 2005-2009 to late Aug. or early Sept. for 2010-2012 (Fig. 1). During the period under study, there were three years for which events could have affected the data. The year 2005 was the first year of data recording, and there were fewer mature trees, so it is not a surprising result that 2005 had the shortest harvest duration. A drought occurred in 2007, which may account for the short, 41-day harvest duration, 9 days shorter than the average range (Fig. 1). While 2010 had the potential to be a bumper year (large FW), Hurricane Ike brought damaging winds to the area in early Sept. resulting in the loss of over 45 kg of unripe fruit in total across the three locations. This produced an overall smaller yield. The year 2010 was also the first year that fruit from the Fox Paw Ridge Farm location were included in the analysis, resulting in an increase in the number of trees and may be a reason that 75% of the fruit were collected by early Sept. (Fig. 1). In contrast, median harvest date, i.e., 50% of fruit collection, for the surrounding years 2009 and 2011 fell in mid- to late-Sept. The year 2010 also had the longest harvest range of 74 days.

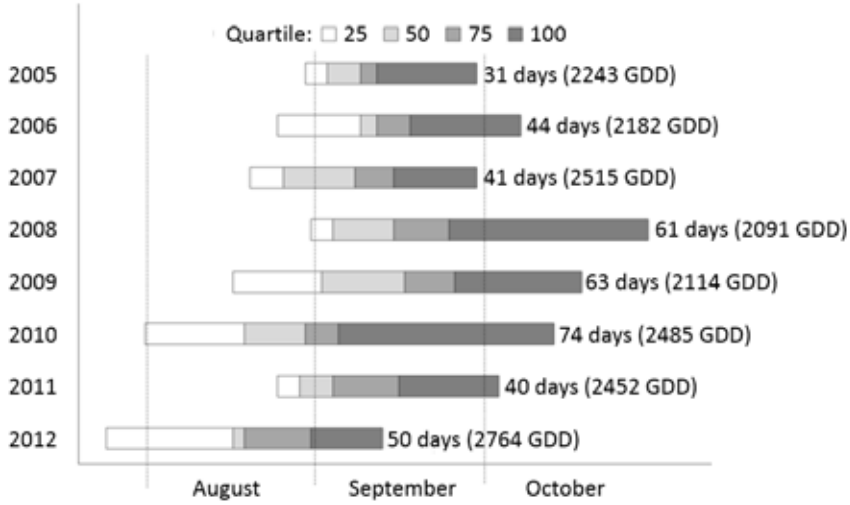

Fig. 1. Pawpaw harvest date ranges (from first to last record) divided into quartiles for 52 pawpaw cultivars grown in Ohio in two suburban and one rural location from 2005-2012, with growing degree days (GDD) as of August 1 for each year indicated in parenthesis.

The average number of harvest days, defined as the number of days that a tree produced harvestable fruit, was 19 days and ranged from 5 to 25 days depending on the year. There was a significant ($p = 0.047$) positive correlation (r = 0.714) between harvest duration and harvest days. Growing degree days (GDD) are shown in Figure 1 and are a measure of the heat accumulation. GDD in this study were calculated as of 1 Aug. for the respective year (Fig. 1). GDD was not correlated with harvest duration (p = 0.830) or the midpoint of harvest, i.e. the number of days required for half of the fruit to be harvested that year (p = 0.693). This suggests that factors other than temperature throughout the entirety of the growing season may be important. For example, research has shown that early season temperatures and crop load can affect both days from bloom to harvest and fruit size at harvest for peach where the relationship between GDD during the first 30 days after bloom was positive for harvest days but negative for fruit weight (Marini, 2018).

The results of this study generally agree with those reported in the most recent Pawpaw Regional Variety Trial (Pomper et al., 2008b) organized by Kentucky State University, the USDA National Clonal Repository for pawpaw. Average harvest duration for the 28 cultivars reported in the trial was 22 days, 4 days longer than the fruit for this study (18 days). This small difference could be related to a number of factors including growing location (Kentucky versus Ohio) or cultivars sampled.

Frequency data for pawpaw average FW for all cultivars and years. A frequency (f) analysis of average FW was conducted for all cultivars (Fig. 2A) and average FW was normally distributed. No previous information about the average FW distribution of pawpaw or other Annonaceous fruits has been reported. As evidenced by the Shapiro-Wilk's test (S-W test) of normality, the average FW over the collection period for all cultivars are normally distributed with a slight positive skew. Individually, 41 of the 52 cultivars exhibited normality for average FW (data not shown). A limitation to this analysis is that average fruit weight per cultivar was used rather than

individual fruit weight. Thus, the individual fruit weight may have a weight distribution that could be obscured by the measurement method employed.

Across all of the cultivars, several variables were significantly correlated. Average FW was correlated with total number of fruit collected (r = -0.21, $p < 0.001$) and number of harvest days (r = -0.11, $p < 0.001$). Total number of fruit also was significantly correlated with number of harvest days and yield (r = 0.62 and r = 0.90 respectively, $p < 0.001$), and yield was significantly correlated with harvest days (r = 0.61, $p < 0.001$). This analysis indicates, among other things, that as the number of total mature fruit increases, average FW decreases. These findings support a generally accepted phenomenon among horticulturalists and one that has been confirmed for pawpaw (Crabtree and Pomper, 2007; Crabtree et al., 2010), but these researchers caution that it is important that the increased costs of hand-thinning are offset by the increased profits brought by larger fruit before it should be recommended to growers (Crabtree et al., 2009).

The average FW for each of the 52 cultivars of pawpaw is shown in Table 1, with twenty-four (24) of the cultivars categorized into a genetic group based on previous research (Pomper et al., 2010) and the remaining 28 cultivars uncategorized because no genetic information was available. The genetic groups were designated based on the name of a member, or in one case two members. The S-W test of normality indicated that the average FW of the 24 cultivars within a genetic group were normally distributed with a positive skew (Fig. 2B). Individually, three of the genetic groups *(Taylor & Wilson, Wabash, and Wells)* were normally distributed, and two *(Susquehanna and Overleese)* did not follow normal distribution for FW (data not shown). The S-W test of normality for the remaining 28 cultivars indicates normality with a high degree of positive skew (Fig. 2C), however, these varieties may be inherently dissimilar from one another and have not had their genetic profiles determined. The positive skew observed in the cultivars that were not placed in a genetic group (Fig. 2C) likely is responsible for the positive skew seen across all 52 cultivars (Fig. 2A).

Comparative analysis of pawpaw across all cultivars. The main effects of location (two suburban, one rural) and year (2008-2012) were analyzed for FW across all 52 cultivars of pawpaw. With respect to location, no significant differences between the three locations were observed for average

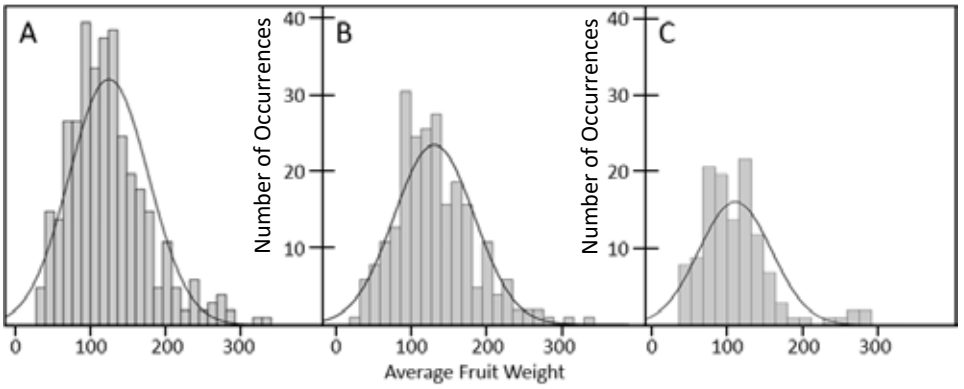

Fig. 2: Frequency (*f*) distribution (number of occurrences of the average fruit weight per cultivar per year) versus average fruit weight (g) for (A) pawpaws of all cultivars grown in Ohio in two suburban and one rural location from 2005-2012 and two subsets: (B) pawpaw fruit characterized into genetic groups by simple sequence repeat markers; and (C) pawpaw fruit of unknown genetic group.

Table 1. Total number of fruit, average fruit weight, total yield per tree, and the number of days between the harvest of the first and last fruit (Harvest Duration) of individual pawpaw cultivars grown in Ohio from two suburban and one rural location from 2005-2012 that are 1) categorized into one of five genetic groupings based on simple sequence repeat markers, 2) of unknown genetic group, and 3) of unknown genetic group and excluded from the data analysis because harvest occurred only once. Values are means ±SD.

Group	Cultivar	Total # of Fruit	Avg. Fruit of Weight (g)	Total Yield (g)	Harvest Duration
1) Categorized into a Genetic Group[z]					
	Overleese Genetic Group				
	‘Davis’	8	244 ± 95	1017 ± 946	3 ± 5
	‘NC-1’	978	172 ± 43	9550 ± 12791	20 ± 13
	‘Rebecca’s Gold’	473	167 ± 59	9953 ± 5396	21 ± 8
	‘Overleese’	1036	160 ± 49	7208 ± 5151	17 ± 8
	‘Shenandoah’	577	153 ± 47	3660 ± 3930	20 ± 10
	‘Sunflower’	1319	148 ± 36	10998 ± 11570	25 ± 15
	‘Taytwo’	261	121 ± 47	3024 ± 3086	13 ± 16
	‘IXL’	8	121 ± 25	4888 ± 6687	22 ± 17
	‘Mitchell’	559	117 ± 34	5706 ± 6976	20 ± 14
	Susquehanna Genetic Group				
	‘Susquehanna’	75	194 ± 76	1846 ± 2392	15 ± 8
	‘SAA Zimmerman’	727	170 ± 24	18182 ± 14847	24 ± 10
	‘Prolific’	116	105 ± 33	2132 ± 1169	13 ± 8
	‘PA Golden 1’	1139	93 ± 28	11161 ± 8147	23 ± 15
	‘PA Golden 3’	6	92 ± 9	276 ± 26	--
	Taylor and Wilson Genetic Group				
	‘Taylor’	181	119 ± 49	2079 ± 1855	9 ± 8
	‘Wilson’	1217	80 ± 28	4433 ± 5120	18 ± 12
	Wabash Genetic Group				
	‘Sweet Alice’	12	141 ± 19	792 ± 684	4.5 ± 5
	‘Potomac’	16	121 ± 53	427 ± 447	3 ± 3
	‘PA Golden 4’	43	107 ± 39	542 ± 473	8 ± 11
	‘Green River Belle’	22	106 ± 22	10818 ± 8016	26 ± 15
	‘Rappahannock’	251	72 ± 23	1218 ± 1247	9 ± 7
	Wells Genetic Group				
	‘Wells’	312	144 ± 46	4672 ± 5779	12 ± 12
	‘Middletown’	33	96 ± 15	1038 ± 119	10 ± 10
	‘Sue’	2087	96 ± 43	10215 ± 11349	19 ± 14
2) Unknown Genetic Group Cultivars					
	‘Mango’	12	210 ± 83	1321 ± 794	5 ± 6
	‘SAB Overleese’	17	208 ± 75	1021 ± 879	1 ± 0
	‘SAA Overleese’	7	156 ± 69	472 ± 90	1 ± 0
	‘Cawood’	13	153 ± 11	667 ± 371	22 ± 4

'Lady D'	12	142 ± 13	822 ± 531	1 ± 0
'KYSU' (Atwood)	1120	141 ± 67	11349 ± 10202	22 ± 12
'Mary Foos Johnson'	121	139 ± 80	1234 ± 1476	10 ± 10
'Estil'	3	136 ±17	734 ± 392	15 ± 13
'Lynn's Favorite'	487	135 ± 55	3791 ± 4471	14 ± 10
'421'	11	132 ± 15	722 ± 10	17 ± 6
'Quaker Delight'	50	127 ± 69	2010 ± 2594	7 ± 9
'Belle'	18	125 ± 26	1194 ±934	8 ± 7
'Tollgate'	217	120 ± 27	3853 ± 2141	17 ± 9
'Broad'	8	112 ±26	483 ± 419	7 ± 8
'Sweet Virginia'	47	110 ± 26	931 ± 675	12 ± 12
'Glaser'	4	103 ± 45	564 ± 639	6 ± 10
'KYSU 2-11'	1682	99 ± 50	8335 ± 9206	33 ± 19
'KYSU 2-7'	882	85 ± 27	5316 ± 4041	24 ± 15
'KYSU Seedling'	303	81 ± 29	2901 ± 2415	22 ± 13
'Ruby Keenan'	12	79 ± 36	359 ± 405	8 ± 12
'SunGlo'	99	79 ± 14	1514 ± 1295	15 ± 9
'Shawnee Trial'	3	77 ± 44	99 ± 12	1 ± 0
'Kristen'	2	76 ± 1	337 ± 261	2 ± 1
'Wild'	944	76 ± 1	264 ±156	11 ± 14
'Convis'	22	74 ± 6	791 ± 565	2.0 ± 1
'Rana'	7	73 ± 23	281 ± 237	5 ± 5
'LA Native'	19	68 ± 10	654 ± 146	15 ± 4
'Cullman Late'	16	10 ± 20	563 ± 212	1 ± 0
3) Unknown genetic group cultivars that were excluded from the analysis				
'PA Golden 2'	1	99	692	1
'Allegheny'	2	96	1338	1
'Forest Keeling'	3	83	250	1
'Vicky Russel'	3	79	238	1
'Pickle'	14	78	1089	1
'Danica'	19	68	1293	1
'Pepper'	4	67	267	1
'Cherokee Ridge'	1	53	532	1

[z] Genetic classifications from (Pomper et al., 2010)

FW (data not shown). With respect to harvest year, significant differences for average FW, yield, and harvest days for all cultivars for each growing year are shown in Table 2. While significant differences were noted, it is challenging to elucidate what caused these differences or discern any patterns. Yearly preharvest factors such as weather could have a significant effect on fruit production, as could soil characteristics (pH or fertility), sunlight, and irrigation. Soil conditions of the suburban locations (loam) were different from that of the rural location (clay). More research is required to determine what environmental factors affect fruit production and harvest duration of various pawpaw cultivars.

Shown in Table 1, the average FW ranged from 10 g ('Cullman Late') to 244 g ('Da-

Table 2. Fruit weight, yield per tree, number of days that individual fruit was harvested (harvest days), and first date and last date of harvest averaged over 52 pawpaw cultivars grown in Ohio in two suburban and one rural location from 2005-2012. Values are means ±SD.

Year	Average fruit weight (g)	Yield (g)	Harvest Days	Harvest Duration
2005	121abc[z] ± 43	679d ± 564	5d ± 6	Aug 29 - Sep 27
2006	153a ± 48	4134bcd ± 6770	13bcd ± 11	Aug 24 – Oct 6
2007	101c ± 47	1254cd ± 1008	9cd ± 6	Aug 19 – Sep 28
2008	100c ± 46	5389abcd ± 4837	21ab ± 15	Aug 30 – Oct 29
2009	138ab ± 54	9145a ± 9087	25a ± 13	Aug 16 – Oct 20
2010	143a ± 61	3013bcd ± 5045	16bc ± 13	Jul 31 – Oct 13
2011	122abc ± 55	6027abc ± 8560	17bc ± 11	Aug 24 – Oct 3
2012	108bc ± 47	6881ab ± 9080	16bc ± 13	Jul 24 – Oct 11

[z] Means within columns followed by common letters do not differ, by Duncan's Multiple Range test, $p<0.05$.

vis'), but both of these cultivars produced few fruit per tree (16 and 8 fruits, respectively). Of the more prolific cultivars, arbitrarily defined as the 19 cultivars that produced more than 250 fruit per tree over the duration of the study, the average FW ranged from 72 g ('Rappahannock') to 172 g ('NC-1').

Comparative analysis of pawpaw from cultivars included in a genetic group. The average FW, yield, and harvest days for the five genetic groups was compared (Table 3). The two most prolific genetic groups in terms of average FW and harvest days were *Overleese* and *Susquehanna*. With respect to average FW, the *Susquehanna* and *Overleese* groups were not significantly different, whereas the *Overleese* group had significantly larger fruit than the groups *Taylor and Wilson, Wabash*, and *Wells*. The *Susquehanna* group had larger fruit than the groups *Taylor and Wilson* and *Wabash*. There were significant differences in harvest days , however harvest days only ranged from 13-19 days. Although *Overleese* and *Susquehanna* share some phenotypical similarities, there is little genotypic commonality between the *Overleese* and *Susquehanna* genetic groups. According to Pomper, et al. (2010) the *Susquehanna* group is distantly similar to the *Wabash* and *Wells* groups, not *Overleese*.

The ramifications of phenotypic similarity coupled with genotypic dissimilarity is difficult to interpret. Pawpaw characteristics have been shown to vary by cultivar. One study re-

Table 3. Number of trees, fruit weight, yield per tree, and number of days that individual fruit was harvested (harvest days) for the pawpaw cultivars grown in Ohio in two suburban and one rural location from 2005-2012 that were characterized into one of five genetic groups by simple sequence repeat markers. Except for number of tree, values are means±SD.

Genetic group (# of cultivars)	Number of trees	Average fruit weight (g)	Yield (g)	Harvest Days
Taylor & Wilson (2)	24	92d[z] ± 39	3747b ± 4509	16ab ± 11
Susquehanna (5)	30	137ab ± 62	7851a ± 10144	19a ± 12
Wabash (5)	30	98cd ± 36	3570b ± 6000	13b ± 13
Wells (3)	30	112bc ± 48	7449a ± 9634	16ab ± 14
Overleese (9)	119	155a ± 53	6517ab ± 8158	19a ± 13

[z] Means within columns followed by common letters do not differ, by Duncan's Multiple Range test, $p<0.05$.

ported that pawpaw size, pulp and skin color, sugar content, and phytochemical content varied in 12 cultivars (Brannan et al., 2015). Polyphenol oxidase, the enzyme responsible for the quick browning of pawpaw pulp, also varied by cultivar (Brannan and Wang, 2017). However, these studies made no attempt to characterize the cultivars based on the genetic classifications from Pomper et al. (2010). It is worth noting that two individual cultivars within the *Overleese* genetic group ('Overleese' and 'IXL') had low polyphenol oxidase activity but what is not known conclusively is the relationship between polyphenol oxidase activity and the onset of deteriorative browning in pawpaw.

Conclusion

Demand and consumption of exotic goods such as pawpaw have grown over the last two decades, and specialty produce is one of the fastest growing segments of the produce industry. Pawpaw has the potential to be a profitable addition to new and existing orchards. Its nutritional value and tropical flavor make it a strong candidate for both fresh and processed markets. For pawpaw to be successfully commercialized, a stronger grower base must be established.

Research must empower growers to select and grow cultivars that show strong market potential based on factors such as large fruit size with fewer seeds, acceptable fruit flavor and texture, large yields per tree, and harvest length. Results from this study provide some data for growers and unmasks opportunities for researchers. Some of the results from this study were already known to experienced pawpaw growers, such as a late-summer onset of harvest ranging from one to more than 2 months with most of the fruit harvest occurring in Sept. Other results are more sophisticated such as the data from this study showing that average FW is normally distributed. Another significant finding is that cultivars in the genetic group *Susquehanna* and *Overleese* have significantly higher average FW and harvest length than other genetic groups. Two individual cultivars within the Overleese genetic group ('Overleese' and 'IXL') have been shown to be less prone to oxidative browning due to their low polyphenol oxidase activity (Brannan and Wang, 2017) and may be potential cultivars of interest.

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About the cover

‘Boysen’ blackberry was an industry standard for nearly 50 years, but until recently its origin was unclear. DNA fingerprinting suggests ‘Boysen’ is a hybrid of ‘Logan’ × ‘Austin Mayes’ and ‘Lucretia’ is not a parent. Photo courtesy of Kim Hummer.