'Summit' had the most consistent berry weight across years, both averaging 1.4 g compared to 1.3 g for 'Premier'.

Subjective ratings of plant and berry characteristics in 1997 and 1998 showed that plant vigor and health, stem scar and flavor were consistent across years (Table 3), while there was an interaction between year and cultivar for fruit color and firmness (Table 4). 'Premier', 'Legacy' and 'Ozarkblue' had good health and vigor, which is reflected in the yields for these cultivars. 'Georgiagem' and 'O'Neal' were the least vigorous. 'Summit' rated highest for flavor followed by 'O'Neal' and 'Georgiagem'. The flavor ratings for 'Ozarkblue' and 'Legacy' were similar to 'Premier'. There was little difference in berry color rating among the varieties, although 'O'Neal' rated lower than the others in both years due to its darker skin color (Table 4). 'O'Neal' had the firmest berries in both years while berries of 'Legacy', 'Ozarkblue', and 'Summit' were similar to those of 'Premier' in firmness. 'Legacy' was significantly firmer in 1998 than 1997, again indicating the possible influence of annual weather patterns on fruit quality. 'O'Neal' had the highest rating for stem scar. 'Summit', 'Premier', 'Ozarkblue', and 'Legacy' also rated high for stem scar. Increasing firmness was associated with a smaller picking scar (r^2 = 0.85). Good firmness and small picking scar are desirable traits for shipping and fresh market. Overall, 'Ozarkblue' rated better for fruit quality variables (stem scar, flavor, color, firmness) compared to 'Premier'. These results suggest that 'Ozarkblue' and 'Legacy' are adapted to the climate of southwest Arkansas and can be recommended for commercial planting.

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Performance of 15 Pecan Cultivars and Selections over 20 Years in Southern Georgia

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ADDITIONAL INDEX WORDS. yield, quality, variety, alternate bearing, trial, *Carya illinoinensis*

SUMMARY. Fifteen pecan (*Carya illinoinensis*) genotypes were evaluated over a period of 20 years in a test orchard located near Tifton, Ga. Genotypes tested included seedling selections ('Candy', 'Maramec', 'Melrose', 'Moreland', 'Sumner', and 'Western Schley'), USDA releases ('Creek', 'Kanza', 'Kiowa', and 'Pawnee'), and USDA selections (USDA 41-19-20, USDA 53-11-139, USDA 53-9-1, USDA 57-7-22, and USDA 64-11-17). Actual yields were measured for each tree in the test throughout the test period and the alternate bearing intensity (I) of each cultivar was calculated. Average annual nut production in years 1 to 10 ranged from 19 lb (8.6 kg) in the precocious cultivar 'Candy' to 6 lb (2.7 kg) in the nonprecocious cultivar 'Melrose'. Although a wide variation was seen in the average yield of clones in years 11 to 20, differences were not significant. A subsample of nuts was taken for each tree annually and percent kernel, nuts/lb, specific gravity, and nut volume were determined. Significant differences were found between clones for each of these traits. Most clones were not acceptable for commercial use in Georgia due to small nut size, poor kernel quality, or excessive alternate bearing. Recommended clones include: 'Pawnee', which produced large nuts of excellent quality with an early harvest date, 'Sumner', which produced large nuts of moderate quality with a late harvest date, and 'Kiowa', a precocious bearer of large, good-quality nuts.

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Pecan is a native North American crop and is the most economically important member of the genus *Carya*. Pecan production in the United States totaled over 209 million lb (95 million kg) in 2000, with a farm-gate value of over $238 million (USDA, 2001). Production in the United States can be broadly categorized into four areas: the southeastern region consisting of Arkansas and Louisiana east through Georgia, Florida, and the Carolinas; the south-central region consisting of Oklahoma and Texas; the southwestern region consisting of New Mexico, Arizona, and California; and a northern region spanning from Nebraska and Kansas east to Kentucky and Tennessee (Wood, 2001).

Pecan regions have different environmental constraints to production. Hot, humid summers and relatively mild winters typify the southeastern region. Because of the large amount of rainfall in the summer, pecan cultivars must have at least moderate levels of resistance to pecan scab (*Cladosporium caryigenum*) so that the disease can be controlled with a spray program. Cultivars with a large nut size and high percent kernel bring maximum prices. Optimum kernel color is a light golden hue and the kernel should separate easily from the shell. Early harvest dates are important, as nuts brought to market before the Thanksgiving and Christmas holidays have higher value. Pecan suffers from severe alternate bearing and cultivars displaying an extreme tendency for this habit have generally not been successful in the southeastern U.S. (Conner and Worley, 2000).

Superior pecan genotypes have been selected only since the mid-19th century, compared to thousands of years for many crop plants. Systematic pecan breeding has been ongoing since the 1940s, and has resulted in the release of many new cultivars with substantial improvement in key horticultural characteristics. However, only two cultivars, 'Stuart' and 'Desirable', make up over half of the mature trees in commercial orchards in Georgia (Florkowski et al., 1999). 'Stuart' was discovered in a seedling orchard and was widely disseminated in the early 1900s when it was the benchmark for high quality (Sparks, 1992). 'Stuart' continues to be popular as a mature tree in Georgia, but new plantings have decreased due in part to its low precocity. 'Desirable' was selected from a cross made in the early 1900s by a nurseryman and became widely planted by the early 1960s (Sparks, 1992). 'Desirable' is currently the most popular commercial cultivar in Georgia and comprised 49% of the trees planted in 1993–97 (Florkowski et al., 1999). 'Desirable' sets the standard for nut quality in the southeastern U.S., and is more precocious than 'Stuart', but requires excellent cultural practices to perform well (Sparks, 1997). Other popular cultivars planted in 1993–97 include 'Sumner' (19%), 'Pawnee' (9%), 'Cape Fear' (9%), and 'Stuart' (6%) (Florkowski et al., 1999).

The Coastal Plain Experiment Station has been involved in pecan cultivar testing for over 75 years. This report analyses the production and quality aspects of 15 pecan genotypes in the experimental orchards at Tifton, Ga. These genotypes are released and unreleased USDA breeding program selections as well as several older cultivars. Trees were grown using University of Georgia recommendations for pecan culture to best simulate the results that might be expected in a commercial orchard.

Materials and methods

The test orchard is located a few miles west of Tifton, Ga. Most of the genotypes in this study is released cultivars and unreleased selections from the USDA breeding program based in Texas (Table 1). Other cultivars developed as seedling selections include 'Candy', 'Maramec', 'Melrose', 'Moreland', 'Sumner', and 'Western Schley'. These cultivars were chosen for inclusion based on initial positive results from other testing locations. This test orchard was developed as a test orchard for the National Pecan Advanced Clone Testing Service (NPACTS) program. The priority of this testing program is to evaluate unrated genotypes for potential use in the breeding program or for suitability as new cultivars.

Most of the trees was planted in 1981–83; however a few trees were planted in 1979 and 1984–86. Three to five trees were evaluated for each clone, with most clones having four replicate trees. Trees were planted into

Table 1. Parentage and origin of pecan cultivars or selections evaluated at Tifton, Ga., 1981–2000.

Clone	Parentage[z]	Origin[y]	Source date[x]
Candy	Seedling	Mississippi, Ocean Springs	1913
Creek	Mohawk x Starking Hardy Giant	Texas, Brownwood	1961
Kanza	Major x Shoshoni	Texas, Brownwood	1955
Kiowa	Mahan x Desirable?	Texas, Brownwood	1953
Maramec	Mahan Seedling?	Oklahoma, Maramec	1933
Melrose	Seedling	Louisiana, Hanna	?
Moreland	Seedling	Louisiana, Powhatan	≈1945
Pawnee	Mohawk x Starking H.G.	Texas, Brownwood	1963
Sumner	Seedling	Georgia, Tifton	≈1932
USDA 41-19-20	San Saba Improved x Mahan	Texas, Brownwood	1941
USDA 53-11-139	Moore x Stuart	Texas, Brownwood	1953
USDA 53-9-1	Mahan x Odom	Texas, Brownwood	1953
USDA 57-7-22	Mahan x Brake	Texas, Brownwood	1957
USDA 64-11-17	Chickasaw x Starking Hardy Giant	Texas, Brownwood	1964
Western Schley	Seedling	Texas, San Saba	1895

[z]Seedling denotes trees planted by man where one or both parents are unknown. Adapted from Thompson and Young (1985) and Sparks (1992).
[y]State, and town or county where original tree was grown.
[x]Year tree was identified, nut planted, or cross made.

Table 2. In-shell nut yields of pecan cultivars or selections each year after transplanting at Tifton, Ga., 1981–2000.

		Avg nut yield/tree each year after planting (lb)[z]										
	Trees	Year										
Clone	(no.)	1	2	3	4	5	6	7	8	9	10	11
Candy	4	0	0	0	1	6	22	23	38	46	56	50
Creek	4	0	0	0	2	5	9	15	25	32	25	63
Kanza	4	0	0	0	0	0	2	19	5	32	10	48
Kiowa	4	0	0	0	2	10	18	17	18	29	30	41
Maramec	4	0	0	0	1	0	5	7	27	14	40	18
Melrose	4	0	0	0	0	0	9	6	20	20	3	48
Moreland	5	0	0	0	1	3	14	18	22	24	38	49
Pawnee	4	0	0	0	0	0	2	4	23	18	33	42
Sumner	5	0	0	0	1	6	9	13	10	22	28	25
USDA 41-19-20	4	0	0	0	1	1	6	15	20	30	61	18
USDA 53-11-139	5	0	0	0	2	8	12	22	36	37	37	42
USDA 53-9-1	5	0	0	0	1	5	15	19	24	24	29	39
USDA 57-7-22	3	0	0	0	1	0	4	17	25	24	15	55
USDA 64-11-17	4	0	0	0	0	0	5	12	14	46	15	35
Western Schley	4	0	0	0	0	4	5	14	21	20	9	55
Significance (P)												

[z]1 lb = 0.45 kg.
[y]Average of years 1 to 10 from planting.
[x]Average of years 11 to 20 from planting.
[w]Alternate bearing index: 1 = complete alternation, 0 = identical yields each year.
[v]Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.
[NS]Nonsignificant.

a single orchard block at a spacing of 40 × 40 ft (12.2 m) [27 trees/acre (67 trees/ha)], with cultivar order randomized within the year planted. Nitrogen was applied annually at 100 lb/acre (112 kg·ha^{-1}), while other nutrients and lime were applied according to leaf or soil analysis . Microsprinkler irrigation was used with one 20 gal/h (75.7 L·h^{-1}) microsprinkler per tree applying water when the matric potential reached –0.1 bar (–10 kPa). Fungicides were applied routinely according to University of Georgia recommendations (Ellis et al., 2000) and insecticides were applied only when an insect buildup occurred.

Each tree was harvested yearly for total nut yield, and a random 50-nut sample was collected from each tree for quality analysis. Nuts were shelled and percentage edible kernel was calculated by weight. Then, kernels were graded as fancy, standard, or amber. Fancy kernels were plump, well-filled kernels of the brightest color. Standard kernels were similar, but darker. Amber kernels were darker than standard kernels and/or had defects. Nut volume was determined by water displacement. Specific gravity is the average nut volume/average nut weight. The fluctuation in yield from year to year was expressed as alternate bearing intensity (I), a measure of intensity of deviation in yield in successive years (Pearce and Dober_ek-Urbanc, 1967). $I = 1/(n - 1) \times \{|(a_2 - a_1)|/(a_2 + a_1) + |(a_3 - a_2)|/(a_3 + a_2) \ldots + |(a_{(n)} - a_{(n-1)}|/(a_{(n)} + a_{(n-1)}\}$, where n = number of years, and $a_1, a_2, \ldots, a_{(n-1)}, a_n$ = yield of corresponding years. I varies from a maximum of 1, which indicates a yield of 0 every other year, to a minimum of 0, indicating identical yields each year. I was calculated using yield data from years 9 to 20. Nuts were harvested when about 90% could be shaken from the tree with a mechanical shaker. Harvest date was determined by averaging the day of the year each cultivar was harvested from 1991–98.

Yield and quality data for each year of growth were calculated for each clone by averaging the values of all the replicate trees of that clone for the given year. Clone values for nut production and percent kernel were calculated as the average of years 1 to 10 and years 11 to 20 separately. Clone values for quality characteristics were calculated by averaging years 1 to 20. Average trait values for each clone were subjected to one-way analysis of variance procedures and mean separation by Duncan's multiple range test ($P = 0.05$) using SigmaStat (SPSS Inc., Chicago) statistical software.

Results and discussion

Average yields were determined for years 1 to 10 and years 11 to 20 (Table 2). Years 1 to 10 broadly represent trees progressing from a nonfruitful stage to fully mature fruiting trees. Average productivity of years 1 to 10 provides a measure of the precocity of a cultivar. Average annual nut production ranged from 19 lb/year in precocious genotypes to 6 lb/year in nonprecocious genotypes. Highly precocious cultivars are economically desirable because economic return on the tree investment is realized sooner (Grauke and Thompson, 1996). However, highly precocious cultivars often overbear as mature trees, setting up a cycle of alternate bearing and increasing variability in kernel percentage (Sparks, 1990). For this reason, cultivars with intermediate precocity such as 'Sumner' have often been more successful cultivars in the long run.

Yield in years 11 to 20 is more representative of mature-tree productivity. Despite the large variation in average yields between clones, differences were not significant. Nonsignificance could be attributed to large differences between trees within a cultivar and relatively low tree numbers, and highlights the difficulties of conducting long-term yield studies on tree crops. Within clone variation is the result of a variety of factors including; genetic differences between seedling rootstocks, limb breakage due

Avg nut yield/tree each year after planting (lb)[z] Year											
12	13	14	15	16	17	18	19	20	Avg. 1–10[y]	Avg. 11–20[x]	*I*[w]
58	84	37	61	59	70	29	79	15	19 a[v]	55	0.62 bcd
5	90	15	40	55	78	15	85	21	11 bcdef	46	0.68 abcd
20	69	12	65	20	99	0	86	21	7 ef	42	0.73 abc
41	50	16	96	20	57	54	96	0	12 bcd	47	0.65 abcd
33	66	31	48	31	75	0	60	5	9 bcdef	37	0.59 cd
3	60	45	28	51	57	17	95	23	6 f	43	0.79 abc
21	78	48	42	74	26	58	26	57	12 bcde	48	0.69 abcd
20	65	46	32	83	33	52	49	60	8 bcdef	48	0.58 cd
59	45	43	64	62	21	69	36		9 bcdef	46	0.53 de
74	27	50	17	61	30	0			13 bc	37	0.85 a
32	77	49	45	73	21	14	54	58	16 ab	46	0.37 e
18	27	60	36	67	22	39	58	43	12 bcde	40	0.81 ab
2	63	57	17	83	30	8	48	7	9 bcdef	37	0.66 abcd
12	77	3	34	90	16	88	67	45	9 bcdef	44	0.69 abcd
7	47	39	52	7	61	0			7 def	33	0.69 abcd
									<0.001	NS	<0.001

to storms and heavy yields, trunk damage from mechanical shaking, and site differences within the orchard. Despite the lack of significant differences, clones at the bottom of the yield rankings such as 'Maramec', USDA 41-19-20, USDA 57-7-22, and 'Western Schley' would probably not yield enough to be profitable in this region.

I provides a measure of a cultivar's tendency to produce alternating high and low yields. *I* values ranged from 0.37 in USDA 53-11-139 to 0.85 in USDA 41-19-20. High *I* values are not always reflected in the yield data because this data is the average of several trees and individual trees within a cultivar may be alternating in opposing years. Cultivars with high *I* values are less likely to be accepted by the industry (Conner and Worley, 2000). *I* values above 0.65 represent an excessive degree of alternate bearing that will be detrimental to the usefulness of the cultivar. However, the recent development of methods to reduce crop load via mechanical thinning of nuts may improve the potential of cultivars which tend to overbear (Smith and Gallott, 1990).

Nut size is an important factor in the value of a pecan cultivar primarily because consumers generally prefer a large nut (Florkowski et al., 2000; Sparks, 1992). This factor is especially important in the southeastern U.S. because nuts are often sold for the early holiday market where high consumer appeal leads to increased prices. Large nuts are also less expensive to shell because nuts are cracked individually and a large, well-filled nut will

Table 3. Comparison of pecan cultivars or selections quality data averaged over all testing years at Tifton, Ga., 1981–2000.

Clone	Nuts/lb[z]	% Kernel	% Kernel grade breakdown[y] Fancy	Standard	Amber	Specific gravity	Nut vol (cm^3)	Harvest date[x]
Candy	78.0 bc[w]	45.3 g	30.9 a	14.3 d	0.2 e	0.85 a	7.3 ij	6 Oct. ef
Creek	55.2 f	48.3 ef	12.9 cde	31.2 bc	4.1 bc	0.79 bc	10.4 de	18 Oct. cd
Kanza	73.2 c	52.0 abcd	33.7 a	17.8 d	0.5 e	0.81 b	7.9 i	8 Oct. e
Kiowa	47.8 h	52.5 abc	15.6 bcd	33.1 bc	3.8 bcd	0.75 ef	13.2 a	21 Oct. bcd
Maramec	53.1 fg	52.8 ab	12.4 de	36.3 b	4.1 bc	0.73 fg	11.6 c	19 Oct. cd
Melrose	66.8 d	51.6 abcd	18.5 bcd	30.9 bc	2.2 cde	0.76 def	9.2 fg	28 Oct. ab
Moreland	60.5 e	51.5 abcd	11.9 de	35.4 b	4.2 bc	0.79 bc	9.7 ef	24 Oct. abcd
Pawnee	55.9 ef	53.8 a	19.8 bc	32.6 bc	1.4 de	0.80 b	10.3 de	3 Oct. ef
Sumner	54.7 f	49.8 cde	15.8 bcd	30.7 bc	2.2 cde	0.76 de	11.0 cd	29 Oct. a
USDA 41-19-20	60.3 e	46.8 fg	13.1 cde	31.5 bc	2.5 cde	0.71 g	10.2 e	21 Oct. bcd
USDA 53-11-139	87.3 a	49.9 bcde	20.9 b	26.2 c	3.1 cd	0.77 cde	7.1 j	9 Oct. e
USDA 53-9-1	49.7 gh	49.1 def	7.5 e	35 b	6.6 a	0.74 ef	12.5 b	24 Oct. abcd
USDA 57-7-22	72.8 c	50.6 abcde	11.1 de	33.5 bc	6.0 ab	0.61 h	10.4 be	25 Oct. abc
USDA 64-11-17	78.7 b	51.8 abcd	6.9 e	43.1 a	1.9 cde	0.77 cd	8.1 hi	30 Sept. f
Western Schley	73.3 c	52.5 abc	21.1 b	25.2 c	6.2 ab	0.76 def	8.7 fgh	16 Oct. d
Significance (*P*)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[z]1 nut/lb = 2.2 nuts/kg.
[y]Percentage of kernels falling into each category.
[x]Average harvest date of Stuart at this location was Oct. 17.
[w]Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

Table 4. Average percent kernel produced by each pecan cultivar or selection each year after planting at Tifton, Ga., 1981–2000.

	Avg % kernel each year after planting											
	Year											
Clone	1	2	3	4	5	6	7	8	9	10	11	12
Candy	---[x]	---	---	48.3	44.4	44.6	44.2	45.1	44.2	46.8	49.2	44.9
Creek	---	---	50.3	53.1	48.8	44.9	50.2	49.8	52.8	47.8	47.0	48.2
Kanza	---	---	---	---	49.6	49.1	52.7	52.8	52.2	51.1	54.2	53.3
Kiowa	-	-	58.6	48.6	52.2	57.4	57.2	47.3	56.1	47.8	54.8	49.5
Maramec	---	---	---	58.5	55.3	53.2	54.3	53.7	56.4	53.9	43.1	56.1
Melrose	---	---	---	57.2	57.1	54.0	51.7	51.7	54.9	51.8	44.1	54.9
Moreland	---	---	---	55.7	53.1	53.7	51.1	50.2	52.9	51.5	42.5	54.7
Pawnee	---	---	---	57.3	54.5	51.4	56.4	54.7	55.3	55.2	53.3	56.4
Sumner	---	---	53.2	55.2	48.0	50.7	48.2	50.6	51.8	44.9	52.7	51.7
USDA 41-19-20	---	---	---	55.6	55.9	45.5	53.3	54.1	54.8	48.2	48.9	45.6
USDA 53-11-139	---	---	54.3	55.3	52.6	51.5	48.1	43.5	35.8	53.1	51.7	51.5
USDA 53-9-1	---	---	---	55.3	53.4	52.7	53.9	51.4	53.3	42.6	48.4	51.5
USDA 57-7-22	---	---	---	64.0	---	11.6	55.7	56.2	41.0	55.2	50.6	63.1
USDA 64-11-17	---	---	---	---	---	57.0	57.1	54.6	52.5	47.4	40.3	53.7
Western Schley	---	---	---	---	59.6	52.8	58.0	54.2	53.9	60.4	52.7	54.5
Significance (*P*)												

[z]Average of years 1 to 10 from planting.
[y]Average of years 11 to 20 from planting.
[x]Indicates there was no yield from any tree of that clone for the corresponding year.
[w]Mean separation within columns by Duncan's multiple range test, $P \leq 0.05$.

produce more kernel weight per nut. However, cultivars producing extremely large nuts often have difficulty filling the nut with kernel, especially when cluster size is also large, resulting in lower quality kernels (Sparks, 1990). 'Desirable' and 'Stuart', the two cultivars most preferred by Eastern shellers (Hubbard et al., 1991), have an average nut size of about 47 and 52 nuts/lb (104 and 115 nuts/kg) respectively (Sparks, 1992).

Nut size is usually determined in the industry as nuts/lb. However, this measurement is substantially influenced by the weight of the kernel so that a poorly filled nut will have a lower value than an equally sized well-filled nut. Nut volume, as determined by water displacement is a more accurate reflection of nut size. For example, 'Pawnee' and USDA 57-7-22 have similar sized nuts at 10.3 cm^3 (1.0 cm^3 = 0.061 $inch^3$) and 10.4 cm^3, respectively (Table 3). However, 'Pawnee' produces a much better developed kernel, which is evident from its higher specific gravity of 0.80 as compared to 0.61 for USDA 57-7-22. This results in 'Pawnee' having a nut size of 55.9 nuts/lb (123 nuts/kg) compared to 72.8 nuts/lb (160 nuts/kg) for USDA 57-7-22. Nut volume ranged from 7.1 cm^3 for USDA 53-11-139 to nearly twice that value, 13.2 cm^3, for 'Kiowa'.

Pecan kernels, rather than the nuts themselves are the product that is sold by the growers. A subsample of the nuts being sold is usually taken and the percentage of nut weight made up of kernel is determined in order to compute the price offered for the lot. The average percent kernel produced by a cultivar is a practical predictor of the value of the cultivar, with a range of 50% to 55% considered to be optimum in a large nut. Percent kernel is largely influenced by the size and development of the kernel in the nut, with a larger kernel producing higher percent kernel. Percent kernel often declines as trees age and begin to produce full crops, due to a decreasing leaf area to fruit ratio (Sparks, 1974). Cultivars with high levels of alternate bearing often have a greater decline in percent kernel because of their tendency to produce heavy crops of poor quality nuts in alternate years. For example, USDA 41-19-20 had a high I value of 0.85 (Table 1). The average percent kernel for this clone dropped from 52.5% for years 1 to 10 to 40.0% for years 11 to 20 (Table 4). This drop highlights the importance of continuing to monitor new selections until the trees reach maturity in order to accurately assess their true potential as cultivars.

Percent kernel is also influenced by nut size and shell thickness. With equal shell thickness, the percentage of the nut volume made up of shell decreases with increasing nut size. Thus, with equal kernel development, the percent kernel of a small nut will be lower than that of a larger nut. Therefore, specific gravity is a better indicator of kernel development than percent kernel (Dodge, 1944), whereas percent kernel is a better predictor of the market value of the cultivar. 'Candy' is a good example of cultivar that produces small, well-filled nuts. Due to its small size, percent kernel is low at 45.3% (Table 3), but its high specific gravity of 0.85 indicates the kernel is plump and well developed.

Percent kernel ranged from 45.3% in 'Candy' to 53.8% in 'Pawnee' (Table 3). Edible kernels were graded into three quality classes based on color, plumpness, and amount of packing material adhering to the kernel surface. Light colored, plump kernels with no adherence of the corky interior shell parts or fuzz are most desirable and were graded as fancy. Amber kernels are dark-colored or poorly filled kernels, or kernels with a large percentage of the surface covered with fuzz. 'Candy' and 'Kanza', had the highest percentage of fancy kernels with (about 67%), while USDA 53-9-1 and USDA 64-11-17 had the smallest percentage of fancy kernels (about 15%).

Harvest date is an important factor in determining the value of a pecan cultivar, especially in the southeastern U.S. (Hubbard et al., 1991). Highest

Avg % kernel each year after planting									
Year									
13	14	15	16	17	18	19	20	Avg. 1–10[z]	Avg. 11–20[y]
43.0	44.4	46.7	46.1	46.7	41.6	43.7	43.3	45.4 c[w]	45.0 cd
47.6	52.5	52.6	50.3	47.8	48.9	30.1	45.7	49.7 abc	47.1 bcd
52.1	50.9	52.4	53.1	47.3	---	50.2	50.0	51.3 abc	51.5 abc
54.4	55.3	48.4	57.2	50.9	52.4	46.5	---	53.1 ab	52.2 abc
54.8	40.3	55.7	56.1	48.7	---	54.0	53.6	55.0 ab	51.4 abc
52.4	52.8	52.7	54.8	50.8	51.1	46.3	37.7	54.1 a	49.8 abc
51.1	52.0	52.9	55.3	43.8	53.4	54.1	46.5	52.6 ab	50.6 abc
55.3	53.0	55.7	50.4	54.1	46.4	55.9	51.2	55.0 a	53.2 ab
51.2	52.8	53.2	52.5	50.2	40.0	40.4	---	50.3 abc	49.4 abc
60.1	46.7	47.9	17.1	6.0	---	---	---	52.5 ab	40.0 d
50.6	53.7	55.1	48.3	53.2	46.6	49.0	47.4	49.3 abc	50.7 abc
44.7	44.4	26.3	50.6	46.2	51.6	46.6	44.3	51.8 abc	45.5 cd
57.5	50.8	61.3	57.3	54.7	51.7	46.6	52.2	47.3 bc	54.6 a
45.4	56.6	53.5	53.8	67.6	44.6	46.9	47.3	53.7 ab	51.0 abc
54.5	53.6	48.5	48.7	21.9	---	---	---	56.5 a	47.8 abcd
								0.032	0.003

prices are generally received for nuts harvested early in the season for sale in the holiday market. USDA 64-11-17 and 'Pawnee' were the earliest cultivars in this test. 'Pawnee' was the only cultivar in this test to combine an early harvest date with a large nut size (10.3 cm^3), giving this cultivar a distinct marketing advantage. The latest cultivar in this test was 'Sumner', with an average harvest date of 30 Oct., a full month later than the earliest cultivars.

Cultivar discussion

'CANDY' is an extremely precocious and prolific cultivar, ranking highest in yield in years 1 to 10 and in years 11 to 20 in this group of cultivars. Despite the fact that it began to alternate as a mature tree, percent kernel did not decrease markedly (Table 3). 'Candy' nuts are too small at 78 nuts/lb (172 nuts/kg) to normally bring a good price in the marketplace, but the kernels are very attractive, and a high percentage of them grade as fancy. The kernels are oily and have exceptionally good taste. Scab resistance has been reported to be good in Alabama (Goff et al., 1993). 'Candy' would make an attractive backyard tree, but the nuts are too small for commercial acceptance in Georgia.

'CREEK' was released in 1996 for its superior precocity, disease resistance, and productivity in high-density plantings (Thompson et al., 1996). In this test, 'Creek' began bearing quickly, but was not as precocious as 'Candy' (Table 1). Nut size was similar to 'Pawnee' and 'Sumner' at 55.2 nuts/lb (122 nuts/kg), but percent kernel averaged only 48.3% (Table 2). 'Creek' had a smaller percentage of fancy kernels due to poor kernel fill and an unattractive wrinkling of the seed coat at the apex of the kernel. 'Creek' was released as a highly productive temporary tree that could be removed as the orchard matured. If kept as a mature tree, nut thinning is likely to be necessary to maintain quality (Thompson et al., 1997).

'KANZA' was released in 1996 for its superior productivity, quality, disease resistance, and cold tolerance (Thompson et al., 1996). 'Kanza' had a low precocity compared to several of the other cultivars (Table 2). Alternate bearing intensity was high in 'Kanza' (Table 2), but percent kernel did not decrease in mature trees (Table 4). Harvest date was early, averaging around 8 Oct. Nut size is too small for most commercial use in Georgia.

'KIOWA' was released in 1976 as a precocious and prolific bearer of large nuts (Madden et al., 1976). Like most precocious cultivars, 'Kiowa' tends to bear alternately as a mature tree (Table 2). 'Kiowa' produced the largest nut in this group at 13.2 cm^3. Quality in most years was good with an average of 52% kernel over all years in the test. However, in years with a high crop load, quality was lower. For example, in years 15 and 19, the two highest yielding years, percent kernel dropped to 48% and 47% respectively. This suggests that without some form of crop thinning it will be difficult to maintain top quality with mature 'Kiowa' trees. Average harvest date was on 21 Oct., about 3 to 4 d after 'Stuart'.

'MARAMEC' was introduced in 1971 as a producer of large, high-quality nuts in Oklahoma (Hinrichs, 1971). As a mature tree, 'Maramec' produced a large number of unfilled nuts (pops) resulting in lower yields. 'Maramec' was also had low yields in another test (Nesbitt et al., 1997) suggesting that this cultivar is not sufficiently productive in the Southeastern U.S. for commercial use. Nut size and kernel percentage was high for 'Maramec' in most years (Tables 3 and 4). Average harvest date was on 19 Oct.

'MELROSE' was released by the Louisiana Experiment Station in 1979 for its superior nut quality and productivity (Young et al., 1979). In contrast to results from Melrose, La. (Young et al., 1979), this test indicates that 'Melrose' is nonprecocious cultivar (Table 2). 'Melrose' trees had a strong tendency to alternately bear as trees matured (Table 2), resulting in a lower nut quality (Table 4). Average harvest date was late at Oct. 28. The poor quality and late harvest date of this cultivar lower its commercial potential for southern Georgia.

'MORELAND' was released in 1990 because it had better yield, kernel quality, production, and/or disease resistance than most standard varieties being grown in Louisiana (O'Barr et al., 1990). Our results confirm those of

O'Barr et al. (1990) that showed 'Moreland' tends to bear alternately as a mature tree (Table 2). Percent kernel of 'Moreland' averaged about 53% for years 1 to 10, but declined to 50% kernel for years 11 to 20 (Table 4). 'Moreland' produces a medium sized nut with an average harvest date of 24 Oct., about 1 week after 'Stuart' (Table 3). 'Moreland' has shown better resistance to scab than 'Desirable' in some tests (Anderson, 1999; O'Barr et al., 1989), and this is a primary reason for its recommendation in Florida. However, other tests have shown 'Moreland' to be more susceptible than 'Desirable' (Goff et al., 1993; Sherman and Gammon, 1977). The tendency of 'Moreland' to alternate in production and a reduced kernel percentage as a mature tree may limit its usefulness for commercial plantings in Georgia.

'PAWNEE' was released in 1985 for its precocious and prolific production of large, high-quality nuts with an earlier maturity than other large nuts (Thompson and Hunter, 1985). The average harvest date for 'Pawnee' at Tifton has been 3 Oct., which is at least 2 weeks earlier than the standard early cultivar 'Stuart'. The large size, good quality, and early harvest date for 'Pawnee' provide a substantial price benefit in most years. Our yield data indicate that 'Pawnee' is not an extremely precocious cultivar like 'Candy' (Table 2). However, yield values may have been reduced due to animal depredration which can be severe on early cultivars in a mixed planting such as this test. Contrary to other reports (Sparks, 1992; Nesbitt et al., 1996), 'Pawnee' did not exhibit a severe degree of alternate bearing in this test (Table 2). Percent kernel was the highest of all cultivars in this group at 54%, and was lower than 50% in only one year (Table 4). 'Pawnee' produces a light colored kernel with excellent quality. However, color darkens quickly in storage, and the kernel can become stained if the nuts are rained on before they are collected, necessitating a prompt harvest to retain maximum quality. The early harvest and good productivity and quality of 'Pawnee' make it a promising cultivar if it is carefully managed (Thompson and Grauke, 2000). However, the early harvest date also makes 'Pawnee' more difficult to incorporate into an existing orchard, especially if only a few trees are planted. Animal depredation can be severe if trees are isolated in an orchard among later maturing cultivars. In order to lessen depredation and facilitate prompt harvesting, 'Pawnee' should be planted in relatively large blocks.

'SUMNER' produced relatively large nuts of moderate quality (Table 3). Percent kernel in this test, 49.2%, is lower than the 52% that has been consistently been reported in previous tests (Anderson, 1999; Nesbitt et. al., 1997; Sparks, 1996; Worley and Mullinix, 1994). The late harvest date of this cultivar, Oct. 29, is a disadvantage. Resistance to scab in 'Sumner' is superior to that of 'Desirable' or 'Stuart' (Anderson, 1999; Goff et al., 1993; Nesbitt et al., 1997; O'Barr, 1992). Planting of 'Sumner' has been increasing in Georgia because it combines large nut size, good kernel quality, and a moderate alternate bearing intensity (Conner and Worley, 2000), with a higher level of scab resistance than found in most commercial cultivars.

USDA 41-19-20 produces a medium sized nut with a high percent kernel as a young tree. As a mature tree it enters an extreme alternate bearing cycle with an ensuing unacceptable decrease in quality.

USDA 53-11-139 is a very consistent producer of well-filled nuts, but late harvest dates and small nut size will limit it usefulness in this market.

USDA 53-9-1 produces a large nut maturing late in the season. Nut quality declined as the trees matured and began alternate bearing.

USDA 57-7-22 produced medium sized nuts with a kernel color that was too dark for commercial acceptability.

USDA 64-11-17 has a very early harvest date but produces a small nut and quality declines as a mature tree.

'WESTERN SCHLEY' is the most widely planted pecan in the southwestern region. 'Western Schley' produces a small, high-quality nut and is very productive in its home region (Sparks, 1992). However, we were not able to control scab on this cultivar even with regular chemical applications. As a result, yields and quality were greatly reduced in many years (Table 2). The small nut size and extreme susceptibility to scab of this cultivar (McEachern, 1994; Sparks, 1995; Thompson and Grauke, 1994) make it unsuitable for use in the southeastern U.S.

Conclusion

Three cultivars were identified in this variety test that have potential for commercial use in Georgia. 'Pawnee' had the highest percent kernel of any clone in this test and produced a large nut about 2 weeks earlier than the standard early variety 'Stuart'. While the early maturity of 'Pawnee' provides a price benefit in most years, it makes 'Pawnee' more difficult to manage because animal depredation may be severe and harvesting must begin before most commercial varieties are ready. To minimize these problems, 'Pawnee' should be planted in relatively large blocks. 'Sumner' produces large nuts of acceptable quality with a late maturity. 'Sumner' displays better scab resistance than most currently used commercial cultivars and has relatively consistent annual production. 'Kiowa' is a precocious producer of large nuts with good quality in most years. However, in years with a large crop, nut thinning may be necessary to maintain acceptable quality.

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