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Performance of Nine Pecan Cultivars and Selections in Southern Georgia

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Abstract

Nine pecan clones were evaluated for 18 years in a test orchard in southern Georgia. Tested clones included six USDA selections, the USDA release 'Sioux', and the seedling selections 'Jackson' and 'Kicklighter #1'. Yields and alternate bearing pattern were measured for each clone. A subsample of nuts was taken annually and percent kernel, nut volume, and specific gravity were determined. Cluster size and harvest date were also determined for each clone. All traits showed significant differences among clones. All clones, except 'Sioux', were unsuitable for commercial use in southern Georgia. 'Sioux' has excellent nut quality, but small nut size, limiting use to situations where high kernel quality brings a premium price.

Introduction

Georgia is the leading pecan producing state in the U.S., with the majority of orchards located in the southern half of the state (22). The southern Georgia climate typifies that of the southeastern pecan production region with hot humid summers and relatively mild winters. Because of the substantial summer rainfall, pecan cultivars must have at least moderate levels of resistance to pecan scab [*Cladosporium caryigenum* (Ell. et Lang.) Gottwald (1982)] if the disease is to be controlled with fungicide. Cultivars with large nut size, light kernel color, high percent kernel, and early fruit ripening generally bring maximum prices and are favored by growers (20). Cultivars exhibiting severe alternate bearing are usually commercially unsuccessful in the southeastern United States. (3).

Pecan production in Georgia is dominated by two cultivars, 'Desirable' and 'Stuart', comprising over half of the bearing trees in commercial orchards (7). Both of these cultivars are "old". 'Stuart' was discovered in a seedling orchard and has been widely disseminated since the early 1900's. 'Desirable' was selected from a cross made in the early 1900's and has been a favored cultivar (20). These cultivars are popular partially because of their large nut size and good kernel quality characteristics. However, scab control has become difficult in some areas for both cultivars. In addition, 'Stuart' has lost favor for new plantings due to low precocity. There is a need for the development of new, high-quality, disease-resistant cultivars suitable for the southeastern U.S.

The Coastal Plain Experiment Station at Tifton, Georgia, has evaluated pecan clones for over 75 years (23). A clone evaluation test plot was established in 1979, and periodically expanded until 1993, to evaluate the suitability of pecan cultivars and selections for commercial use in southern Georgia. Test clones included grower selected seedling trees, released cultivars, and unreleased selections from the USDA-ARS breeding program (10). Clones were chosen for a variety of reasons including large nut size, early ripening, and precocity. Cultural practices in the test orchard follow the Georgia Extension Service recommendations to simulate conditions found in commercial orchards (5). Evaluations of clones planted

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in 1979-1983 have been previously reported (2, 4, 23). This report summarizes the results of clones planted from 1984-1986.

Materials and Methods

The test orchard is located a few miles west of Tifton, in south central Georgia. Six of the clones are advanced selections, and one, 'Sioux', is a released cultivar from the USDA-ARS breeding program based in Texas (Table 1). The two remaining clones, 'Jackson' and 'Kicklighter #1' are seedling selections. The majority of trees were planted in 1984-1986, although a few trees were planted in 1981. For analysis, tree data were blocked according to tree age rather than calendar year.

Three to six trees were evaluated per clone. Trees were planted into a single orchard block at a spacing of 12.2 m x 12.2 m (67 trees / ha), with cultivar order randomized within the year planted. Nitrogen was applied annually at 112 $kg \cdot ha^{-1}$, while other nutrients and lime were applied according to leaf or soil analyses. Microsprinkler irrigation was used with one 75.7 liters / h microsprinkler per tree applying water when the matric potential reached -0.1 bar (-10 kPa). Fungicides were applied following Georgia Extension Service recommendations (6) and insecticides were applied when insect spray thresholds were reached.

Each tree was harvested yearly for total nut yield, and a random 50-nut sample was collected from each tree for quality analyses. Nuts were shelled and percentage edible kernel was calculated by weight. Kernels were then graded as fancy, standard, or amber. Fancy kernels were plump, well-filled light-colored kernels. Standard kernels were similar, but darker. Amber kernels were darker than standard kernels and/or had defects. Nut volume was determined by water displacement. Kernel yield was calculated by multiplying the nut yield by the percent kernel of the sample. Specific gravity is average nut weight / average nut volume. Annual yield fluctuation was expressed as alternate bearing intensity (I), a measure of intensity of deviation in yield in successive years (18). $I = 1 / (n-1) \times \{|(a_2 - a_1)| / (a_2 + a_1) + |(a_3 - a_2)| / (a_3 + a_2) \ldots + |(a_{(n)} - a_{(n-1)})| / (a_{(n)} + a_{(n-1)})\}$, 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 9-18. Nuts were harvested when ≈90% could be shaken from the tree with a mechanical shaker. Harvest date was estimated by averaging the day of the year each cultivar was harvested from 1991-2002.

Yield and kernel 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 age. Clone values for nut production, kernel production, and percent kernel were calculated as the average of years 1-10 and years 11-18. Clone values for quality characteristics were calculated by averaging years 1-18. Average trait values for each clone were subjected to one-way analysis of variance (ANOVA) procedures and mean separation by Duncan's multiple range test (P=0.05) using SigmaStat (SPSS Inc., Chicago, Ill.) statistical software.

Results and Discussion

Yields were averaged into years 1-10, which provide a measure for the precocity of a clone, and 11-18 to provide an estimate of mature tree productivity (Table 2). Average annual nut production in years 1-10 ranged from 1.5 and 1.6 kg in the non-precocious 'Jackson' and 'Kicklighter #1' clones to 6.4 kg in USDA 53-3-36. The most precocious clones at this site were 'Cape Fear' and 'Candy' which were planted in 1979 and 1981, and averaged 7.7 and 8.6 kg of nuts in years 1-10 (2). Mature tree nut yields varied from 11.8 to 27.3 kg. Annual in-shell yield of 'Pawnee' and 'Sumner', popular commercial cultivars, planted in 1981 in this test were 21.1 and 22.0 kg for years 11-18 (4).

Kernel yield is a function of total nut yield of the tree and quality of nuts produced, and is a useful measure of actual

Table 1. Parentage and origin of pecan cultivars or selections evaluated at Tifton, Ga., 1981-2002.

Clone	Parentage[Z]	Origin[Y]	Source Date[X]
USDA 49-1-182	Mahan x Stuart	Texas, Brownwood	1949
USDA 49-20-112	Brake x 43-01-20 (Brooks x Carmichael)	Texas, Brownwood	1949
USDA 53-3-36	Brooks x Stuart	Texas, Brownwood	1953
USDA 55-12-17	Nugget x Barton	Texas, Brownwood	1955
USDA 56-6-148	Mahan x Stuart	Texas, Brownwood	1956
USDA 63-16-182	Mohawk x Starking Hardy Giant	Texas, Brownwood	1963
Jackson	Seedling	Mississippi, Ocean Springs	1917
Kicklighter #1	Seedling	Georgia, Tattnall	≈1980
Sioux	Schley x Carmichael	Texas. Brownwood	1943

[Z]Seedling denotes trees planted by man where one or both parents are unknown.
[Y]State, and town or county where original tree was grown.
[X]Year tree was identified, nut planted, or cross made.

saleable product. Average kernel yields were 0.91 to 2.9 kg in years 1-10 and 5.9 to 13.9 kg in years 11-18 (Table 2). USDA 49-20-112, USDA 53-3-36 and 'Sioux' were among the highest kernel producers, while 'Jackson' and USDA 56-6-148 were among the lowest (Table 2).

The alternate bearing index (*I*) provides a measure of a cultivar's tendency to produce alternating high and low yields. *I* values ranged from 0.46 in 'Kicklighter #1' to 0.83 in USDA 53-3-36 and USDA 63-16-182 (Table 2). In general, cultivars with *I* values above 0.65 have an excessive degree of alternate bearing that will be detrimental to the usefulness of the cultivar unless methods to reduce alternation are employed (3).

Nut size is an important factor in the value of a pecan cultivar. This is primarily because consumers usually prefer a large nut (20, 8). However, cultivars producing extremely large nuts often have difficulty filling the nut with kernel, especially when cluster size is also large. This results in lower quality kernels (19). USDA 49-1-182 and 'Jackson' had the largest nuts in this test (Table 3). However, 'Jackson' had a lower cluster size, 1.6 vs. 2.0, and lower yields (Table 2) than USDA 49-1-182 and

Table 2. In-shell nut yield, alternate bearing intensity (*I*), and kernel yield of pecan clones at Tifton, Ga., 1981-2002.

Clone	Trees (no.)	In-shell nut yield (kg/tree) Avg. years 1-10	In-shell nut yield (kg/tree) Avg. years 11-18	*I*[Y]	Kernel yield (kg/tree) Avg. years 1-10	Kernel yield (kg/tree) Avg. years 11-18
USDA 49-1-182	4	4.0 bc[Z]	16.0 cd	0.79 a	2.0 bc	7.8 de
USDA 49-20-112	5	5.6 a	27.7 a	0.60 ab	2.6 ab	13.9 a
USDA 53-3-36	6	6.4 a	23.8 ab	0.83 a	3.3 a	11.2 abc
USDA 55-12-17	3	3.7 bcd	16.7 cd	0.69 ab	2.0 bcd	8.4 cde
USDA 56-6-148	6	3.7 cd	15.0 cd	0.79 a	1.6 cd	5.9 e
USDA 63-16-182	3	1.8 de	15.2 cd	0.83 a	0.91 d	7.7 de
Jackson	4	1.6 e	11.8 d	0.77 a	0.86 d	6.2 e
Kicklighter #1	3	1.5 e	19.5 bc	0.46 b	0.82 d	10.0 bcd
Sioux	4	5.4 ab	24.4 ab	0.78 a	2.9 ab	13.0 ab
Significance		$p<0.001$	$p\leq0.001$	$p=0.024$	$p<0.001$	$p<0.001$

[Y]Alternate bearing index: 1=no crop in alternate years, 0 = identical crop each year. Calculated using in-shell nut yields of years 9-20.
[Z]Mean separation within columns by Duncan's multiple range test at $P\leq0.05$. Values sharing a common letter are not statistically different.

Table 3. Comparison of pecan clone quality data averaged over all testing years at Tifton, Ga., 1981-2002.

Clone	Cluster size[X]	Nut weight (g)	Specific gravity	Nut volume (cm^3)	Harvest date[Y]
USDA 49-1-182	2.0 b[z]	10.5 b	0.73 c	14.6 a	30 Oct. a
USDA 49-20-112	3.0 a	6.9 de	0.73 c	9.6 c	24 Oct. ab
USDA 53-3-36	3.0 a	5.7 f	0.75 bc	7.7 e	24 Oct. ab
USDA 55-12-17	2.1 b	6.6 e	0.69 d	9.8 c	26 Oct. ab
USDA 56-6-148	2.4 b	7.8 c	0.69 d	11.8 b	22 Oct. b
USAD 63-16-182	2.5 ab	6.1 e	0.76 bc	8.2 d	7 Oct. d
Jackson	1.6 c	11.2 a	0.80 a	14.3 a	22 Oct. b
Kicklighter #1	2.1 bc	7.4 cd	0.77 ab	9.7 c	14 Oct. bc
Sioux	3.0 a	6.2 e	0.79 a	7.9 de	20 Oct. bc
Significance	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$

[X]Average from years 1991-2002.
[Y]Average harvest date of Stuart at this location was Oct. 17.
[Z]Mean separation within columns by Duncan's multiple range test at $P\leq0.05$. Values sharing a common letter are not statistically different.

produced a higher quality kernel as measured by specific gravity (Table 3) and % kernel (Table 4). The standard cultivars 'Desirable' and 'Stuart' have an average nut size of approximately 13 and 12 cm^3 respectively (23).

Kernel quality in this test was measured by specific gravity and % kernel. Specific gravity ranged from 0.69 in USDA 55-12-17 and USDA 56-6-148 to 0.80 in 'Jackson' (Table 3). Percent kernel is a key quality characteristic by which pecan crops are judged commercially. Percent kernel of the crops produced by individual trees usually declines with tree age and production of full crops (19). However, precipitous drops in percent kernel are a sign that the tree is producing more nuts than it can fill. This is usually associated with a high degree of alternate bearing. For example, USDA 56-6-148 had an average of 48% kernel in years 1-10, but this declined to 39% kernel in years 11-18. However, not all clones fit this pattern. 'Sioux' had the highest percent kernel as both a young and a mature tree with no decline as trees aged (Table 4). This is despite the fact that 'Sioux' had a higher cluster size (Table 3) and higher average kernel yield (Table 2) than USDA 56-6-148. However, 'Sioux' has a much smaller nut size (Table 3), which may facilitate kernel development.

Edible kernels were graded into three quality classes based on color, plumpness, and amount of packing material adhering to the kernel surface. Light kernel color is seen as desirable because it is associated by consumers with freshness and quality (12). 'Sioux' had the highest percentage of fancy kernels because of its attractive, bright, well-filled kernels (Table 4). Conversely, USDA 49-1-182 produced very dark kernels, and thus has almost no fancy kernels.

Harvest date is an important factor in determining cultivar value, especially in the Southeast (11). Highest prices are generally received for nuts harvested early enough in the season to be sold in the holiday market. A new cultivar ideally should have a harvest date at least as early as 'Stuart' (the industry standard for an early nut) which has an average harvest date of October 17 at the test location. Late maturing cultivars such as 'Sumner' can be successful, but must also possess other outstanding traits (such as disease resistance) (4).

USDA 49-1-182 is a non-precocious selection with mediocre nut and kernel production (Table 2). Percent kernel was low in all testing periods (Table 3). A very low percentage of fancy kernels was attributed to its dark color and the adherence of interior corky shell material on the kernel surface ("fuzz"). This selection had the largest nut size of this group of clones and

Table 4. Percentage kernel and kernel grade of nine pecan clones tested at Tifton, Ga., 1981-2002.

Clone	% Kernel Years 1-10	%Kernel Years 11-18	% Kernel Years 1-18	% Kernel grade breakdown in years 1-18[Y] % Fancy	% Standard	% Amber
USDA 49-1-182	49.1 cd[Z]	48.6 b	48.8 b	1.1 e	40.9 a	6.8 a
USDA 49-20-112	51.6 bc	50.2 ab	50.7 b	19.8 c	28.5 bc	2.4 b
USDA 53-3-36	51.6 bc	48.4 b	50.2 b	30.3 b	18.2 d	2.2 bc
USDA 55-12-17	53.2 ab	50.7 ab	51.8 ab	5.8 de	40.0 a	6.1 a
USDA 56-6-148	48.0 d	39.5 c	43.3 c	9.1 d	32.8 b	1.8 bc
USDA 63-16-182	51.4 bcd	50.6 ab	50.9 b	20.0 c	27.3 bc	3.6 b
Jackson	53.9 ab	52.6 ab	53.1 ab	30.4 b	22.3 cd	0.5 c
Kicklighter #1	51.9 bc	49.6 ab	50.3 b	17.4 c	30.7 b	2.2 bc
Sioux	56.0 a	55.9 a	55.9 a	44.4 a	11.3 e	0.2 c
Significance	$P \leq 0.001$	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$	$P<0.001$

[Y]% of kernels by weight falling into each category.
[Z]Mean separation within columns by Duncan's multiple range test at $P \leq 0.05$. Values sharing a common letter are not statistically different.

a modest fruit cluster size of 2.0 (Table 4), but was unable to produce an acceptable quality kernel. Harvest date was later than desired, averaging about Oct. 30. Low productivity and poor kernel quality make this selection unsuitable for commercial production.

USDA 49-20-112 had the highest yields, as a mature tree, of all clones in this test group (Table 2). Percentage kernel and nut size were mediocre and specific gravity was low (Tables 2, 3). Kernel color was light, but in many years the kernels had an unattractive speckling on the seed coat. This selection had relatively stable production, but kernel quality was not high enough to warrant recommendation for this region.

USDA 53-3-36 was a productive selection which tended to bear alternately as a mature tree (Table 2). Small nut size and poor kernel quality as a mature tree make this selection unsuitable for commercial operations.

USDA 55-12-17 had moderate but consistent production (Table 2). Percent kernel was good in young trees, but dropped in mature trees (Table 4). A major limitation of this selection is a very dark kernel color resulting in a low percentage of fancy kernels (Table 3). Kernel quality is not high enough in this selection for recommendation.

USDA 56-6-148 produced a large, long nut with the lowest percentage kernel of this group. Nut and kernel production were also unsuitably low (Table 2).

USDA 63-16-182 is a non-precocious selection which is also unproductive as a mature tree (Table 2). Nut size is small for this region (Table 3). Percent kernel was low but acceptable for a small nut (Table 4). The outstanding feature of this selection is its early harvest date, that is two weeks prior to 'Stuart'. The male parent of this cross was 'Starking Hardy Giant', a northern cultivar with an early harvest date. This selection is a sibling of 'Pawnee' which is earlier, more productive, and has better quality (4, 21).

'Jackson' is an old cultivar that was introduced in 1917 (13). It was an exceptionally light bearer in this test (Table 2) and in others (1, 16, 17). Although nut size and quality were good, this cultivar is not productive enough to be recommended for commercial orchards.

'Kicklighter #1' is a grower selection from eastern Georgia. This selection was the least precocious of this group of cultivars, but mature tree yields were average (Table 2). This selection was a consistent bearer of nuts of medium quality (Table 4). Nut size was small for this region (Table 3). This selection would probably be acceptable as a mature tree, but the long immature phase and middling quality limit its value.

'Sioux' was released in 1962 by the USDA (14). 'Sioux' ranked second in kernel production as both a young and mature tree (Table 2). Alternate bearing is a problem, but nut quality remained high in the "on" years. 'Sioux' is well-known for producing extremely high quality kernels (9, 15, 20). Kernel percentage was high as both a young and mature tree (Table 4). Kernel color is very light and nearly all kernels graded as "fancy" (Table 4). 'Sioux' is susceptible to scab in this region, but the disease can be controlled with fungicides (9, 20). The biggest limitation of this cultivar is a smaller nut size than is commonly grown for this market (Table 3). 'Sioux' is an outstanding producer of high-quality nut meats, and may be useful where smaller nut size does not limit the price received. (9).

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