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Performance of 14 Pecan Genotypes in South Alabama

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Baldwin and Mobile Counties in Alabama lead the state in pecan production. The climate of these two counties, which border the Gulf of Mexico, is typical of other coastal regions in the southeastern United States, with high annual rainfall (165 cm), high humidity, and warm temperatures throughout a long growing season (270 days). This climate promotes the development of pecan scab (*Cladosporium caryigenum*), the most damaging pecan disease. Pecan growers in south Alabama must apply 8 to 10 fungicide sprays throughout the growing season on most commercial pecan cultivars to provide adequate protection from this disease. Additionally, cultivars must have at least a moderate level of genetic resistance to scab to be successful. Cultivars like 'Tejas' and 'Wichita' that have poor resistance to scab are not productive in this region, even with a full season fungicide program (10).

On September 12, 1979, high winds from Hurricane Frederic destroyed many pecan orchards in Baldwin and Mobile Counties. Orchards having cultivars with poor branch strength, like 'Desirable,' were decimated (12). Since that time, many growers have been dissatisfied with the annual production, nut quality, and disease resistance of many pecan cultivars. In 1983, a trial was established in Baldwin County at the Gulf Coast Substation (GCS), near Fairhope, Alabama, to determine the suitability of new or different pecan genotypes for commercial production in the region.

Field grown pecan seedlings grafted to selected cultivars were obtained from a commercial nursery and transplanted on 12.2 m x 12.2 m spacings at GCS in February 1983. The experiment was a randomized complete block design with four blocks and 14 test selections. Within each block, there were five adjacent trees of each cultivar, totaling 20 trees per genotype. Test selections included 12 named cultivars; 'Cape Fear,' 'Cheyenne,' 'Choctaw,' 'Davis,' 'Elliott,' 'Forkert,' 'Jackson,' 'Kiowa,' 'Maramec,' 'Melrose,' 'Stuart,' and 'Sumner,' and two unreleased selections from the USDA pecan breeding program, 'USDA 53-9-1' (Mahan x Odom) and 'USDA 61-6-67' (Mohawk x Starking Hardy Giant). USDA clone '61-6-67' has recently been released as 'Creek' (14), partly due to characteristics identified in this experiment.

Trees were intensively cultured, using procedures recommended by the Alabama Cooperative Extension Service (5, 8). Trees were severely pruned in early years to promote strong central leaders and wide angle branching, since the site is prone to wind damage. Nut production in early years was therefore reduced. Weeds were controlled by herbicide applications, maintaining a sod and strip orchard floor. Soil and leaf samples were taken annually, and fertilizers were accordingly applied. Fungicide applications were begun at bud break, and a full-season schedule was maintained. Insects were controlled when scouting indicated an economic injury level was present. Drip irrigation was

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Table 1. Budbreak dates among 14 pecan cultivars or selections, Fairhope, AL; 1990-1994.

Cultivar or selection	Date of bud break					
	1990	1991	1992	1993	1994	Mean
Elliott	March 19	March 24	March 13	March 25	March 22	March 20
Cape Fear	March 21	March 22	March 23	March 23	March 23	March 22
Kiowa	March 19	March 25	March 23	March 28	March 25	March 24
Davis	March 21	March 25	March 24	March 26	March 27	March 24
Creek	March 21	March 28	March 26	March 28	March 23	March 25
Jackson	March 22	March 28	March 23	March 29	March 27	March 25
USDA 53-9-1	March 22	March 30	March 26	March 29	March 28	March 27
Melrose	March 22	March 29	March 27	April 2	March 28	March 27
Cheyenne	March 31	March 29	March 28	March 30	March 27	March 29
Choctaw	March 29	March 30	March 28	March 30	March 30	March 29
Sumner	April 2	April 4	April 2	April 6	April 1	April 3
Maramec	April 6	April 9	March 31	April 2	March 31	April 3
Forkert	April 2	April 7	April 1	April 6	March 31	April 3
Stuart	April 6	April 12	April 3	April 9	April 3	April 6

supplied to all trees according to established recommendations for pecans (2). Data included: date of bud break, date of nut maturity, yield of each cultivar, in-shell nut weight, percent edible kernel, and kernel grade percentages (percentages of #1, #2, #3, and reject kernels). Yield values reported here represent marketable yield. If percent edible kernel value for a given cultivar was less than 35% in a particular year, corresponding yields were considered unmarketable and assessed a value of zero. Nut scab ratings were made in 1994. Trunk size measurements were made in January 1995.

Date of budbreak. Mean date of budbreak for 'Stuart' (April 6th) was later than all other cultivars. 'Forkert,' 'Maramec,' and 'Sumner' also broke dormancy late. 'Elliott' was earliest, with dates rang-

Table 2. Variation in pecan nut maturity among cultivars and years, Fairhope, AL.

Cultivar or selection	Year					
	1989	1990	1991	1992	1993	Mean
	Date of nut maturity[z]					
Elliott	10/1	10/4	10/8	10/1	10/19	10/6
Creek	9/30	10/3	10/7	10/13	10/20	10/8
Cheyenne	10/3	10/8	10/9	10/7	10/19	10/9
Cape Fear	10/19	10/11	10/10	10/14	10/26	10/16
Choctaw	10/15	10/15	10/14	10/21	10/27	10/18
Davis	10/17	10/9	10/14	10/26	10/27	10/18
Kiowa	10/20	10/12	10/21	10/20	11/11	10/23
Maramec	11/6	10/17	10/25	10/21	11/10	10/28
Forkert	11/7	10/19	10/29	10/23	11/3	10/28
Melrose	11/8	10/19	11/1	10/15	11/8	10/28
Sumner	11/6	10/29	10/21	11/2	11/8	10/31
Stuart	11/6	10/30	11/2	11/6	11/11	11/4
Jackson	11/6	10/31	10/29	11/6	11/18	11/5
USDA 53-9-1	11/16	10/30	10/31	11/10	11/18	11/8

Table 3. Occurrence of nut scab on 14 pecan cultivars or selections at Fairhope, Ala., in September 1994, in an orchard receiving a full-season fungicide program.

Cultivar	Mean nut scab	Maximum nut scab
Cheyenne	4.2 a[zy]	5
Maramec	2.7 b	4
Cape Fear	2.0 c	5
Stuart	2.0 c	4
USDA 53-9-1	1.6 cd	5
Choctaw	1.5 de	3
Forkert	1.5 de	2
Kiowa	1.2 de	3
Davis	1.2 de	2
Creek	1.1 e	2
Jackson	1.1 e	2
Melrose	1.0 e	1
Elliott	1.0 e	1
Sumner	1.0 e	1

[z]Mean separation in columns by Duncan's multiple range test, $p = 0.05$.
[y]Scale: 1-5; 1 = no scab, 5 = worst scab (51-100% of shuck surface covered).

ing from March 13 to March 25. The range from earliest to latest for all cultivars to break dormancy was 17 days (Table 1). Spring freezes did not occur after budbreak of any cultivars in the years when budbreak date was recorded (1990-1994). However, in the 12-year period from 1983-1994, spring freezes have occurred as late as March 22nd, which could have a negative impact on production of cultivars which commence growth early, such as 'Elliott' and 'Cape Fear.'

Nut Maturity. Nut maturity, measured in 1989-1993, varied as much as 47 days among the 14 test cultivars (Table 2). 'Elliott' and 'Creek' had the earliest harvest dates. Early nut maturity contributes to severe depredation from birds in coastal regions, because of low competition from other nut tree species (10). In this study, depredation from birds and squirrels was also severe on very late-ripening selections such as 'USDA 53-9-1' and 'Jackson,' which had maturity dates as late as November18 and November 22 (Table 2).

Scab ratings. Rainfall accumulation during the seven months of pecan production (April-October) was above average in 7 out of 12 years from 1983 to 1994. The 30 year average precipitation for these months is 98.6 cm. In 1991 rainfall during this period was 126 cm, with 72 cm falling from May 1st to July 31st. In 1994 the 7 month seasonal accumulation was 101 cm, with 54 cm falling from May through July. Rainfall prohibited fungi-

Table 4. Production of kernels, trunk cross-sectional area (CSA), and yield efficiency expressed as g kernels produced per cm^2 CSA for 14 pecan cultivars or selections at Fairhope, AL.

Cultivar or selection	Kernels produced 1986-1994 (g/tree)	Trunk CSA in 1994 (cm^2)	Yield efficiency (g kernel/cm^2 CSA)
Creek	29200 bc[z]	20.9 de	85.0 a[z]
Kiowa	38500 a	24.8 b	78.4 ab
Sumner	27000 bcd	22.6 bcd	66.8 bc
Forkert	34700 ab	26.9 a.	60.9 cd
Melrose	23500 cde	22.5 cd	57.8 cde
Choctaw	26600 bcd	24.5 bc	56.8 cde
USDA 53-9-1	21000 cdef	23.3 bc	49.1 def
Cape Fear	27400 bcd	27.1 a	47.5 def
Davis	22100 cde	24.5 bc	47.0 def
Stuart	19800 defg	24.0 bc	43.6 ef
Cheyenne	12000 g	19.6 e	39.9 fg
Maramec	16000 efg	22.8 bcd	39.3 fg
Elliott	19000 defg	28.9 a	28.7 gh
Jackson	12700 fg	27.4 a	21.1 h

[z]Mean separation in columns by Duncan's multiple range test, P = 0.05.

Table 5. Age of tree, nut weight (all cultivars), % kernel (all cultivars), seasonal rainfall, rainfall during nut development; and crop load; Gulf Coast Substation, Fairhope, AL; 1988-1994.

Year	1988	1989	1990	1991	1992	1993	1994	Mean (all years)
Tree age (yrs)	6	7	8	9	10	11	12	—
Nut wt. (g)	8.0	8.7	9.1	8.8	10.1	8.9	8.0	9.0
% kernel	50	44	48	n/a	47	44	33	46
Rainfall (cm) April-October	117	118	66	126	67	96	101	99
Rainfall (cm) 6/10-8/1	26	43	26	34	19	29	40	31
Rainfall (cm) 8/1-9/20	67	9	9	23	17	32	19	25
Crop load (kg/ tree)	0.5	3.4	4.8	15.2	8.1	24.2	0.6	8.0

cide spraying for periods longer than 12 days in both years; consequently, incidence of scab was severe. Goff et al. (1993), rated all 14 cultivars for leaf and nut scab in August 1991, and found differences. Differences were also found in 1994 (Table 3). 'Stuart,' 'Cheyenne,' 'Cape Fear,' 'Maramec' and 'USDA 53-9-1' exhibited nut scab ratings of 4 or greater (1-5 scale), despite adherence to a full-season fungicide spray schedule. 'Stuart' and 'Cape Fear' were considered highly resistant to scab when they were introduced to the region. Their inferior ratings support the theory that local scab isolates adapt to overcome resistance in some pecan cultivars (15).

'Elliott,' 'Sumner,' and 'Melrose' exhibited no nut scab in 1991 or 1994, and are among cultivars reported to be highly resistant to scab (1, 10, 16). 'Jackson,' 'Davis,' 'Creek,' 'Kiowa,' 'Choctaw' and 'Forkert' exhibited very little scab when a full-season fungicide spray schedule was followed. We have observed over the years, however, that scab control is much more difficult in a large planting of a cultivar than in a cultivar test, and we believe that scab incidence would be higher in commercial plantings than in this experiment.

Trunk size. Analysis of trunk diameter measurements made in January 1995, revealed significant differences among cul-

Table 6. Kernel grades and nut weight of 14 pecan selections at Fairhope, AL.

Cultivar or selection	Kernel grade percentages					Inshell nut wt (g)[z]
	No. 1	No. 2	No. 3	Reject	Edible kernel[z]	
Forkert	41.7 a[y]	4.5 ef	10.6 cdef	2.8 bcd	56.8 a	9.8 bc
Elliott	39.3 ab	4.0 f	6.8 f	0.6 d	50.0 bcd	6.2 k
Jackson	37.6 abc	5.3 cdef	9.3 def	2.3 bcd	52.3 b	12.2 a
Cape Fear	33.7 bcd	6.0 bcdef	8.8 ef	4.6 ab	48.5 cde	8.3 h
Sumner	33.0 cd	6.2 bcdef	12.3 cde	0.7 cd	51.5 b	8.8 fg
Cheyenne	30.8 de	4.7 def	12.0 cdef	5.1 a	47.4 de	6.5 j
Mararnec	30.7 de	4.5 ef	15.4 bc	3.6 ab	50.7 bc	10.0 b
Melrose	28.5 def	8.1 abc	15.3 bc	1.0 cd	51.9 b	7.5 i
Kiowa	24.7 efg	8.8 ab	19.3 ab	3.0 abc	52.8 b	10.1 b
Creek	23.2 fgh	8.0 abcd	14.5 bcd	4.1 ab	45.8 e	8.7 g
Davis	21.5 gh	7.6 abcde	11.0 cdef	4.0 ab	40.1 f	9.3 de
Choctaw	18.7 h	7.7 abcde	23.5 a	4.0 ab	49.8 bcd	9.9 bc
Stuart	18.3 h	9.6 a	14.3 bcde	2.6 bcd	42.7 f	9.1 ef
USDA 53-9-1	17.6 h	10.1 a	20.7 a	4.5 ab	48.4 cde	9.6 cd

[y]Mean separation in columns by Duncan's multiple range test, p = 0.05.
[z]Data from 1991 excluded, due to small crop resulting in uncontrolled pests.

Table 7. Nut size and percent edible kernel of cultivars at Fairhope, AL, as compared to other locations.[z]

Cultivar or selection	No. of reports	Nut size rank	Kernel % rank
Cape Fear	11	5[y]	11
Cheyenne	6	6	6
Choctaw	7	3	6
Davis	2	1	2
Elliott	7	4	6
Forkert	6	2	5
Jackson	2	1	2
Kiowa	8	1	6
Maramec	4	2	4
Melrose	6	5	6
Stuart	6	4	5
Sumner	8	7	6
USDA 53-9-1	3	2	3
Creek	5	1	5

[z]Adapted from: Aitken, 1987; Anderson and Crocker, 1990; Calcote and Scott, 1988; O'Barr and Rachal, 1987; Sherman et al., 1982; Sparks, 1982; Thompson and Hunter, 1983; Wood, 1982; Worley, 1986; Young et al., 1974; Young 1978.
[y]1 = highest rank (largest nut size or highest percent kernel).

tivars (Table 4). 'Elliott,' 'Jackson,' 'Cape Fear,' and 'Forkert' could be separated as the largest trees, while 'Cheyenne,' 'Creek,' 'Sumner' and 'Melrose' were the smallest, making them more suited to higher density plantings.

Kernel quality and nut size. General comments among commercial pecan buyers suggest that pecans grown in south Alabama tend to be larger than average in size, but lower than average in kernel fill compared to nuts produced in other southeastern areas (J. Sasser, personal communication). Heavy rainfall during nut expansion and insufficient rainfall during kernel fill are believed to be the primary causes. In south Alabama, the period of nut sizing generally commences in early June and continues until early August, while most kernel filling is in early August and through mid-September (7).

Average percent kernel across all cultivars in this study was lowest in 1989, 1993, and 1994 (Table 5). The extremely low values for 1994 were not included in means, because crop load was extremely light, shuck decline was prevalent, and damage from hickory shuckworm (*Cydia caryana*) was not properly prevented. Rainfall was indeed disproportionate in 1989 and 1994, favoring the nut size period (June. 1-August 1). However, kernel fill was comparatively good in 1990, a year with the same pattern of rainfall. Consideration must be given to other factors known to affect pecan kernel quality, such as crop load, excess soil moisture, and reduced sunlight (13). In 1993, rainfall was evenly distributed across both nut development periods, but crop load was excessive (4). In 1988 and 1990, crop

Table 8. Inshell nut yield of 14 pecan cultivars or selections at Fairhope, AL.

	Year									
Cultivar	1986	1987	1988	1989	1990	1991	1992	1993	1994	Total
Kiowa	29.0	102	75	399	1097	879	1475	1022	32	5112
Creek	10.1	62	37	412	299	1110	382	1990	0	4303
Forkert	0.9	9	9	87	235	1085	412	2326	0	4164
Cape Fear	4.3	81	81	549	838	2034	132	0	5	3724
Davis	0.6	12	47	256	439	1096	149	1647	0	3646
Choctaw	5.8	50	41	147	379	1277	379	1340	0	3619
Sumner	0.0	4	9	89	403	600	823	1584	52	3564
Stuart	0.0	2	3	49	245	621	500	1868	0	3289
Melrose	2.4	20	19	162	128	404	1002	1353	15	3105
USDA 53-9-1	0.6	40	49	185	210	331	937	1108	37	2899
Elliott	0.3	5	3	75	53	859	237	1456	0	2688
Maramec	0.0	4	10	49	133	386	404	1083	0	2069
Jackson	0.0	4	9	98	137	543	271	605	37	1703
Cheyenne	6.7	82	51	396	84	733	124	168	0	1645

load was relatively light. Prevalence of cloud cover causing reduced net photosynthesis was not measured, but may be a major factor in south Alabama, where rainfall has been above average in 7 of 12 years since 1983.

'Forkert' had a mean edible kernel percentage of 57, significantly higher than all other cultivars (Table 6), but 8% lower than values reported elsewhere for 'Forkert' (12). Compared to six published cultivar trials, mean kernel percentage for 'Forkert' at GCS ranked 5th (Table 7). Values for other test cultivars compared to these reports were likewise low, except for 'Kiowa' and 'Sumner.' These comparisons do support comments made by commercial buyers that pecans grown in south Alabama tend to have lower percent kernel.

Analysis of kernel grades show 'Forkert' had a significantly higher percentage of #1 kernels than other cultivars except 'Elliott' and 'Jackson' (Table 6). Other cultivars with high #1 grade percentages include 'Sumner' and 'Cape Fear.' 'Elliott' and 'Sumner' had the lowest percentages of reject kernels, while 'Cheyenne' had the highest. 'USDA 53-9-1' 'Choctaw,' and 'Kiowa' had a high percentage of dark-colored, #3 grade kernels. 'Davis' had the poorest total edible kernel percentage, and should not be planted because of this consistent problem.

The 14 cultivars encompassed a wide range of nut sizes from very small ('Elliott') to very large ('Jackson') (Table 6). Average nut weight of 'Davis,' 'Jackson,' 'Kiowa,' and 'Creek' was higher in this trial compared to other reports, but 'Cheyenne,' 'Melrose,' and 'Sumner' were not (Table 7). Nut weights of 'Cape Fear' and 'Stuart,' two of the most common commercial cultivars in south Alabama, were average compared to other published values. Large nut size is a desirable cultivar trait in south Alabama, because of retail marketing opportunities; however, 'Elliott' has very good local retail popularity despite its small size (6.15 g/nut).

Yield. 'Kiowa' was the most precocious cultivar, yielding 29 kg of marketable inshell nuts per ha in 1986 (4th leaf after planting), and 102 kg per ha in 1987 (5th leaf). 'Cape Fear,' 'Cheyenne,' and 'Creek' were also precocious, yielding from 62 to 82 kg/ha in 1987. 'Elliott,' 'Stuart,' and 'Maramec,' were among the least precocious (Table 8).

'Kiowa,' 'Creek,' and 'Forkert' were the the most productive cultivars through 12 growing seasons. These three cultivars had the highest inshell production per tree, and the highest production of kernels per tree (Table 4). Cumulative inshell production for 'Kiowa' (1986-1994) was more than 5,100 kg per hectare. Other top yielding cultivars were 'Cape Fear,' 'Davis,' 'Choctaw,' and 'Sumner.' 'Cheyenne' and 'Jackson,' the two least productive cultivars, yielded less than 2,000 kg per hectare (Table 8). Yield efficiency or kernel production per square cm of cross-sectional trunk area was greatest for 'Creek,' which is a very productive cultivar with small tree size (Table 4), and should be suitable to higher density plantings.

Alternate bearing was exhibited early in this study by 'Kiowa,' 'Creek,' and 'Cheyenne' (Table 8). All 24 cultivars exhibited patterns of alternate bearing similar to that experienced throughout south Alabama in recent years. In 1991 and 1993, yields were very heavy, "on-crop" years statewide, while production in 1994 was extremely low. Five cultivars; 'Kiowa,' 'Melrose,' 'Sumner,' 'Maramec,' and 'USDA 53-9-1' had increased yields in 1992 after a large 1991 crop. With the exception of 'Maramec,' these cultivars were also able to produce small crops in 1994.

Summary. Pecan cultivars must possess a combination of desirable traits to be acceptable for commercial production. In south Alabama those desirable traits include robust disease resistance, strong canopy form, good kernel quality, and annual productivity. Of the 14 cultivars examined for 12 years at GCS, all but 'Cheyenne' demonstrated adequate resistance to pecan scab under the conditions of this experiment, given full-season use

of fungicides. Many, however, were disappointing in yield and nut quality. In addition to 'Cheyenne,' 'USDA 53-9-1,' 'Davis' and 'Maramec' should not be planted in this region given their poor nut quality and low yields. 'Melrose,' 'Jackson,' 'Elliott' and 'Stuart' additionally have not produced enough marketable inshell nuts to economically 'break even' in a commercial orchard in south Alabama. They may be productive as older, permanent trees, if initially planted with more precocious types.

'Kiowa,' 'Cape Fear,' 'Choctaw,' and 'Creek' demonstrated excellent precocity and yield. All four demonstrated serious alternate bearing and nut quality problems early in this trial, and are commonly known to produce lower quality nuts as tree age increases. Given these problems, a grower in south Alabama should only plant these cultivars as temporary trees or should plan to practice crop thinning. Crop load thinning with trunk shakers is an effective practice (6, 11), and should extend the economic potential of these cultivars.

Two cultivars; 'Forkert' and 'Sumner,' demonstrated a combination of good traits and deserve recommendation for planting in south Alabama. While less precocious than other cultivars, production of kernels and yield efficiency was very good (Table 4). 'Sumner' has excellent scab resistance and has strong tree form (12). 'Forkert' is also a strong tree, and scab incidence has been low at this location so far, but it has scabbed badly in one other southeastern cultivar trial (9). A drawback common to both cultivars is late nut maturity (Table 2) which can be a marketing disadvantage in some years. Continued testing is needed to identify pecan cultivars that possess desirable traits and can have a positive influence on pecan production in south Alabama.

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