



Staminate pecan flowers.

New pecans for California

G. Steven Sibbett □ Tommy E. Thompson □ Nick Troiani

Pecan is developing as a crop of economic importance in California. A major portion of the state's approximately 2,550 acres of pecans is planted in the southern San Joaquin Valley (Fresno, Tulare, and Kern counties), where the summer is hot and dry and the fall normally rainless, facilitating late harvest of the crop. Smaller acreages occur in adjoining counties, and additional acreage is being planted in northern California. Several pecan shelling and processing facilities now exist in California, and the industry includes an Association of Pecan Growers.

Clones of pecan, *Carya illinoensis* (Wang.) K. Koch, have been developed for the arid west by the U.S. Department of Agriculture (USDA) Pecan Breeding Program (W. R. Poage Pecan Field Station, Brownwood, Texas) and by private breeders. These programs have resulted in the recommendation of 'Wichita' as a main fruiting clone in California, with 'Western Schley' and 'Cheyenne' as pollenizers. This combination has been precocious and productive. Nuts mature in late October and early November, usually soon enough for sale in the holiday market.

Weaknesses of these clones include late ripening, brittle branches, and poor crotches resulting in breakage (especially in 'Wichita'), poor shell seal in 'Cheyenne', and general alternate bearing. Consequently, there continues to be a need for precocious clones that mature earlier, maintain heavy, high production and quality, are less prone to alternate bearing, and develop strong trees when grown in western climates. This report summarizes five years of performance data (1982-86) from tests of USDA and other selected pecan clones in California with particular attention to these attributes.

Methods

In 1976, we selected 21 clones from the Brownwood USDA Pecan Breeding Program and private breeders that had potential for economic production in California. Scion wood was collected and hot-water-treated in Texas for the insect pecan nut casebearer (*Acrobasis nuxorella*). The treated scions were shipped to the Linwood Nursery in Turlock, California, where they were grafted to VC168, a pecan seedling rootstock selected by that nursery for its excellent vigor and uniform growth.

Pecan trees are monoecious (male and female flowers separate, but on the same tree), and male and female flowers bloom at different times. Of the 21 clones, 10 were protandrous (pollen shedding before pistil receptivity; referred to as Type I clones by the industry) and 11 were protogynous (pistil receptivity before pollen shedding; referred to as Type II clones). It is always recommended that a Type I clone be planted with a Type II for maximum pollination and subsequent productivity.

In the spring of 1977, following one year's growth in the nursery, three trees of each clone were dug and replanted in Tulare at the conventional spacing of 30 by 30 feet (48 trees per acre). The planting was made in a commercial pecan orchard of 'Wichita' and 'Cheyenne' clones that had been planted in 1976.

The orchard soil is a Foster sandy loam, an alluvial soil, which is fairly sandy, slightly calcareous, contains few salts, and has a fairly high percentage of organic matter. It absorbs and holds moisture well and roots penetrate it readily. It is considered one of the best soils for tree fruit and nuts in the district.

We compared the performance of the experimental and commercial clones. We also collected performance data from a nearby commercial orchard of 'Western Schley' planted in 1977 and 'GraBohls' planted in 1979. Table 1 lists the 25 clones and their parentage.

Each season, beginning in the spring of 1982, we recorded leafing date, duration of pollen shedding, duration of pistillate bloom, and peak pistillate bloom. The leafing date was when terminal shoots had emerged and leaves had begun to reflex substantially. Pollen shedding and pistillate bloom were determined by observing bloom every three days. The beginning and end of pollen shedding were estimated by observing the shedding that resulted from shaking several branches of each tree of each clone. First pistillate bloom was the date when the first pistillate flower could be found with a glistening stigmatic surface. The date when most stigmas were observed in this condition was considered peak pistillate bloom. Termination of pistillate bloom was recorded when glistening pistils could no longer be found in the tree.

Each year we recorded the date on which earliest commercial harvest could begin. We defined that as the date when shucks would separate readily from shells, shells had brown coloration, packing tissue between cotyledons was brown, and nut removal was adequate for a commercial harvest. The period between leafing date and harvest date is the fruit development period. At harvest, the three test trees of each clone except 'GraBohls' and 'Western Schley' were harvested and pounds of dry nuts per tree recorded. Production weights were recorded from clones in the commercial orchard and divided by the total number of trees of that clone.

Nut quality of a 1-pound subsample of dry nuts from each clone except 'Western Schley' was evaluated in each harvest year at the USDA W.R. Poage Pecan Field Station. The evaluations included percent kernel, nut size (by weight), and kernel color, the major components of nut value. Similar quality criteria for 'Western Schley' nuts were evaluated by the Dried Fruit Association of California, because that crop was being processed in California.

Leafing and harvest dates

Leafing and harvest dates are important when evaluating the suitability of a pecan clone for planting. In areas with short growing seasons, the leafing date indicates the probability of a clone being injured by spring frost. Harvest date affects marketing; the holidays (Thanksgiv-

ing and Christmas) are the most profitable times to sell pecans. Further, potential problems caused by bad weather before and during harvest can be minimized by growing clones with an early-ripening crop.

The average leafing and harvest dates during the five-year observation period for all clones in our evaluation are compared with those for 'Wichita', the standard fruiting clone in this district (table 1).

The average date of leafing for 'Wichita' in this district was March 21; the latest recorded date for this clone was April 5 in 1982, and the earliest, March 12 in 1983. Each year, we recorded the leafing date of each clone, calculated the number of days before or after the leafing date of 'Wichita', and averaged the difference for the five-year period.

Harvest dates for each clone were averaged for the 5-year period, and from these figures, we calculated the average number of days the clone could be harvested before or after 'Wichita'. The earliest harvest date recorded for 'Wichita' was October 22, 1984, and the latest date, October 28 in 1982 and 1985.

Our results are similar to those of other investigators evaluating pecan clones, in that the leafing and harvest dates appear to be independent of one another, indicating that the period required for fruit development varies among clones. For example, early-leafing clones did not necessarily harvest early and clones leafing out later than 'Wichita' required fewer days, in many cases, to mature a harvestable crop.

Tulare is an "early" district for fruit and nut ripening. In cooler, more northerly areas of California, also suitable for pecans, leafing and harvest dates may occur up to three weeks later.

Blooming habit

Durations of pollen shedding and pistillate receptivity for each clone were averaged for the five-year period (fig. 1). Interestingly, clones classified as protandrous (Type I) in Texas, with pollen shedding preceding pistil receptivity, did not generally exhibit this trait when grown under California conditions. In fact, for all Type I clones except 'Western Schley', the average beginning date of pistil receptivity was slightly ahead of pollen shedding.

Varying degrees of dichogamy (separation of pollen shedding and pistillate receptivity) occur, depending on the clone. With few exceptions, Type II clones exhibited relatively complete dichogamy when bloom dates were averaged, while Type I demonstrated the least. In some cases, such as 'Cheyenne', 'Cherokee', 'Cape Fear', 'Caddo', 64-11-17, and 'Western Schley', dichogamy was essentially nonexistent. Examples of annual dichog-

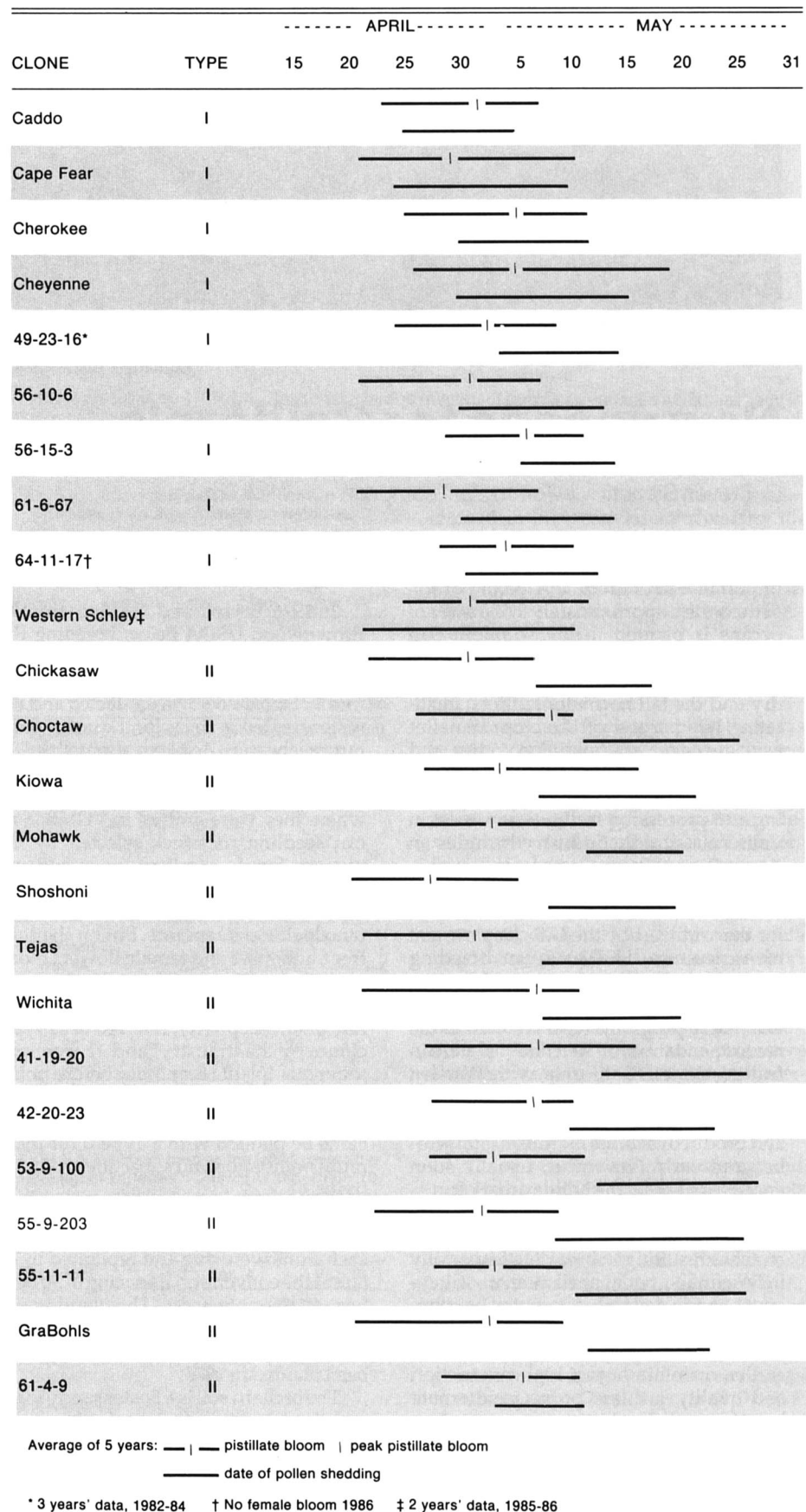


Fig. 1. Average period of pollen shedding, pistillate bloom, and peak pistillate bloom for selected pecan clones, 1982-86, Tulare, California.

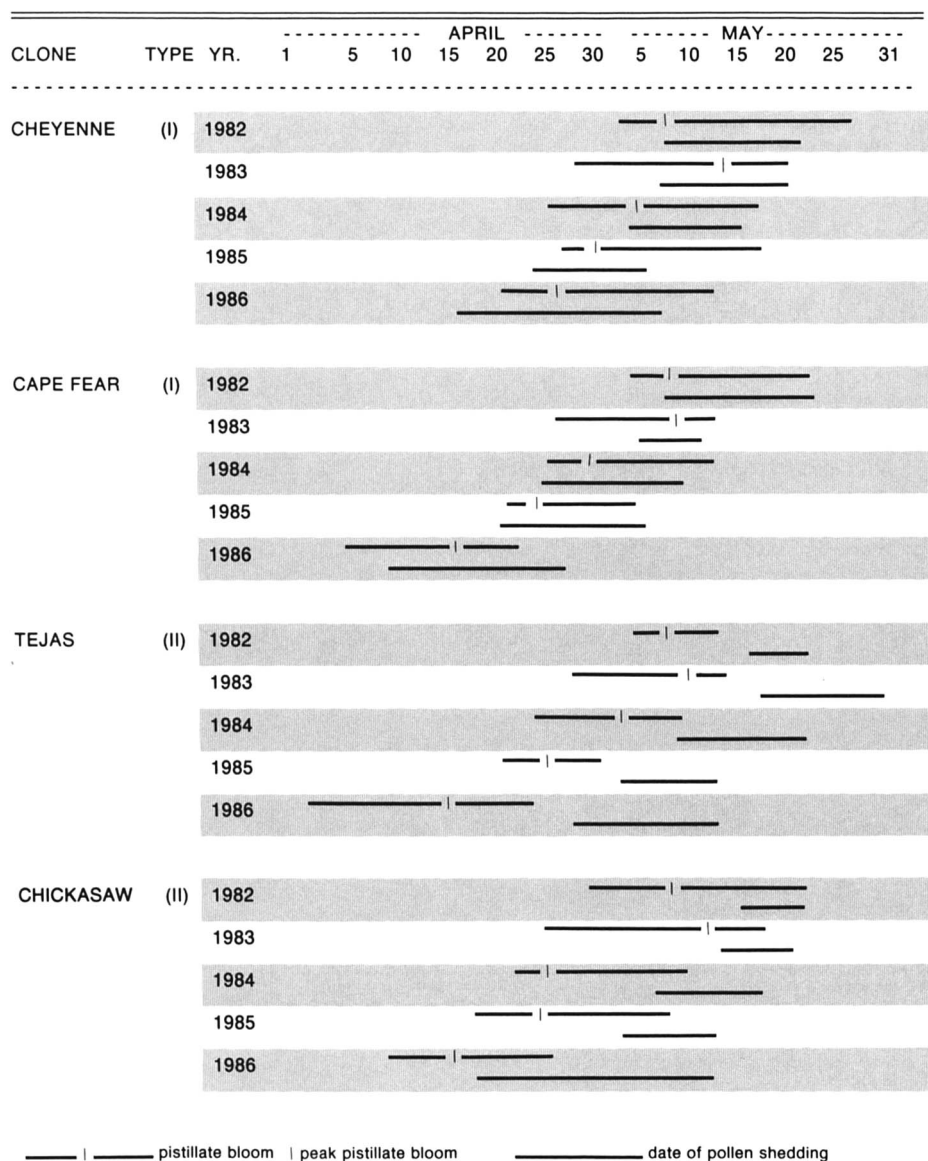


Fig. 2. Examples of year-to-year blooming habits of two representative Type I and Type II pecan clones, Tulare, California.

amy of two representative Type I and Type II clones are presented in figure 2.

Adequate pollination is critical for maximum production of pecans. Many clones in this evaluation, especially those of Type I, showed incomplete dichogamy (an overlap of pollen shedding and pistil receptivity). More data would need to be collected, however, before such incompleteness would be considered sufficient for adequate self-pollination and economic cropping of solid blocks planted to only one cultivar. We also know from other research that self-pollination produces other problems in pecan production, such as smaller nut size and fewer nuts per cluster.

Pecan nut quality

The main components of pecan quality that determine the economic value of the

crop are kernel percentage, nut size, and kernel color. Nut quality is largely a genetic trait, which can be influenced by climate, cultural practices, insect control, and harvest timing. Our trees were well managed and were maintained insect- and disease-free. Nut samples were collected the day we felt the earliest commercial harvest could commence, then promptly hulled and dried.

The kernel percentage is used to determine the value of the nuts. The value of a pound of inshell pecans is calculated by multiplying an industry-established "value per point" by percent kernel (as a decimal). For example, \$1.80 per point times 0.64 (average proportion of kernel for 'Wichita') equals \$1.15 per inshell pound. Thus, high-kernel-yielding nuts are worth more per inshell pound than those yielding less kernel.

The percentage of the nut that is kernel is largely a genetic trait. Acceptable pecan clones are those having nuts with greater than 55 percent kernel. Clones with a lower percentage usually need other, overriding attributes, such as nut size and early harvest, to be profitable.

Nut size determinations are based on the number of kernels per pound (table 1). Generally, pecan clones requiring more than 70 nuts to weigh 1 pound are considered unacceptable for the inshell trade and must be shelled. The inshell trade prefers nuts that require, at most, 60 to 65 nuts to make a pound. Of the clones listed in table 1, 'Caddo', 'Cheyenne', 'Cherokee', 'Tejas', 48-15-3, 56-15-3, 61-4-9, and 49-23-16 cannot be considered acceptable for "inshell" because of their small nut size and are used as shelled nuts.

Although nut size is largely under genetic control, environmental factors can cause substantial variability within each cultivar from year to year. Crop load affects ultimate nut size; smaller nuts result from heavy crops, and the largest nuts occur when the crop is light. Also, poor cultural practices, such as inadequate pest control, fertilization, and/or irrigation reduce ultimate size.

Kernel color is an important component of pecan value. The lightest colored kernels are the most valuable; darkening decreases value. Light-colored kernels also store longer and are less likely to become rancid.

The industry rates color on a scale of 1 to 10, with 1 indicating the lightest, and 10 the darkest. Kernel value would be adversely affected by a rating greater than 3, and clones rated higher than 5 would be unacceptable. Kernel color in our evaluations ranged from 1.6 for 'GraBohls' to 3.6 for 'Cherokee' (table 1). We did not obtain kernel color ratings for 'Western Schley'.

Yield

The crop from each tree was shaken, hulled, dried, weighed, and results averaged for each harvest year (table 1). For most clones, 1982, the sixth season, was the first year the crop could have been considered commercial. 'Wichita' and 'Cheyenne' clones in the commercial orchard were one year older and in 1981 bore economic crops, which were not weighed. This age adjustment is important when one compares yields. 'Choctaw', 'Kiowa', and selections 53-9-203, 55-11-11, 48-15-3, and 61-4-9 bore only trace crops in 1982 and did not bear commercially until 1983. Yields were not obtained from 'Western Schley' and 'GraBohls'.

The first four to five years of bearing do not accurately indicate the ultimate yield capability of a pecan clone. However, precocity of a pecan clone, onset of commer-

TABLE 1. Characteristics of pecan clones grown and evaluated in Tulare, California, 1982-86

Clone (and parentage)*	Leafing (days before [-] or after Wichita)†	Harvest date†		Days be- tween leaf- ing and harvest†	Nut quality (avg.)‡			Average dry weight/tree¶						Total lb, 5 yr	Av./ tree /yr
		Average date	Days before [-] or after Wichita		Kernel per- cent	Num- ber nuts/lb	Kernel col- or§	Crop year							
								'82	'83	'84	'85	'86			
					%	lb-----								lb----	
TYPE I#															
Caddo (Brooks x Alley)	10	10/19	-3	213	58	81	2.0	7	11	25	35	13	91	18	
Cape Fear (Seedling [North Carolina])	1	10/20	-2	214	54	57	2.2	11	18	13	13	29	84	17	
Cherokee (Schley x Evers)	11	10/17	-5	211	56	72	3.6	24	1	72	4	80	180	36	
Cheyenne (Clark x Odom)	16	10/21	-1	215	57	81	2.3	3	22	21	31	24	110	22	
48-15-3 (Majors x Evers)**	15	10/12	-10	206	56	87	3.0	Tr††	2	5	—	—	7	—	
49-23-16 (Brake x Sioux)	20	10/8	-14	202	63	71	2.2	Tr	2	6	14	3	25	5	
56-10-6 (Shoshoni x Cherokee)	4	10/6	-16	200	60	68	3.0	1	5	12	5	19	42	8	
61-6-67 (Mohawk x Starking Hardy Giant)	7	10/15	-7	209	53	56	1.9	12	10	25	34	11	92	19	
64-11-17 (Chickasaw x Starking Hardy Giant)	19	9/30	-22	194	58	69	2.6	4	16	14	52	16	102	20	
56-15-3 (Odom x 44-12-259)	18	10/23	1	217	64	70	2.2	1	3	19	69	6	98	20	
Western Schley (San Saba seedling)	0	10/27	5	221	58	58	—	—	—	—	—	—	—	—	
TYPE II#															
Chickasaw (Brooks x Evers)	7	10/8	-14	202	56	68	2.1	13	17	22	43	17	111	22	
Choctaw (Success x Mahan)	16	10/27	4	220	59	50	2.4	Tr	17	22	43	39	121	24	
Kiowa (Mahan x Odom)	5	11/1	9	225	58	53	2.4	Tr	20	16	27	30	93	23	
Mohawk (Success x Mahan)	12	10/12	-10	206	56	49	2.5	7	17	10	48	18	99	20	
Shoshoni (Odom x Evers)	-1	10/2	-20	196	54	64	2.7	25	34	28	36	55	178	36	
Tejas (Mahan x Risien #1)	9	10/14	-8	208	54	71	1.7	16	17	28	36	61	158	32	
41-19-20 (San Saba Imp x Mahan)	16	10/24	2	218	58	56	1.9	9	26	10	42	25	112	22	
42-20-23 (McCulley x Odom)	14	10/26	4	220	55	50	2.4	1	5	25	27	4	61	12	
53-9-100 (Mahan x Odom)	16	10/20	-2	214	56	47	2.9	1	17	7	17	13	55	11	
53-9-203 (Mahan x Odom)	10	10/24	2	218	56	59	2.3	Tr	12	11	24	28	75	19	
55-11-11 (Major x Shoshoni)	19	10/6	-16	200	54	69	2.0	Tr	3	4	18	9	34	8	
Wichita (Halbert x Mahan)	—	10/22	—	216	64	63	2.8	35	31	25	51	41	182	36	
GraBohls (Seedling x Odom)	3	10/28	6	222	61	55	1.6	—	—	—	—	—	—	—	
61-4-9 (Schley x Starking Hardy Giant)	16	10/3	2	218	58	71	1.9	Tr	4	7	22	12	45	11	

NOTE: Nursery-grafted trees planted 1977. Wichita, Cheyenne, and Western Schley planted 1976. GraBohls planted 1979.

* Origins (and state): Cape Fear — Pender Co. (North Carolina); Western Schley — E. E. Risien (Texas); and GraBohls — O.S. Gray (Texas); all other clones — USDA (Texas).

† All data based on 5-year average (1982-86), except for 48-15-3 (based on 3 years' data, 1982-84), and 61-4-9 and 49-23-16 (4 years' data).

‡ Data are averages of sample evaluations (at W.R. Poage Pecan Field Station, Brownwood, TX) from 5 harvest years, 1982-86, except for the following: KERNEL PERCENT — 4 years of data available for GraBohls, Wichita, Cheyenne; 3 years for 61-4-9, 48-15-3. NUMBER NUTS/LB — 4 years for GraBohls, 61-6-67, Western Schley; 3 years for Wichita, 61-4-9, 48-15-3, Cheyenne. KERNEL COLOR — 4 years for GraBohls, 61-6-67; 3 years for 61-4-9, Cheyenne, Wichita, 48-15-3.

§ Ratings on a scale of 0 to 10: 1.0 to 3.5 = lightest (best); 4.0 to 5.5 = light brown; 6.0 = medium brown; 10.0 = darkest (worst).

¶ Average of three trees. GraBohls and Western Schley harvest not collected.

Type I = protandrous (pollen shedding before pistil receptivity). Type II = protogynous (pistil receptivity before pollen shedding).

** 48-15-3 grafted to Pawnee in spring 1985.

†† Tr = trace.

cial production, and even the tendency for alternate bearing can sometimes be identified from the first five years of harvest weights. For example, 'Cherokee', a precocious cultivar, also appears to be a strong alternate bearer. 'Shoshoni', also precocious, has not yet shown alternate bearing, yet both cultivars have similar total and average production. For this reason, the average production of a pecan cultivar may be misleading, since the tendency toward alternate bearing is not taken into account.

Breakage

Each clone was inspected each year limb or branch breakage. 'Wichita', in the commercial orchard, was the only cultivar with excessive breakage, even though annual dormant and follow-up summer pruning were conscientiously performed. 'Wichita' still produced the second highest yield, and so it will be interesting to see how much limb breakage this clone undergoes as a mature tree. Breakage in all

other clones was minimal and of little consequence.

Summary

Early production and performance data obtained over five growing seasons in this experiment have indicated several promising clones for the California pecan industry and a number that should not be considered. The standard clones 'Wichita' and 'Western Schley' continue to perform well, although limb breakage continues to be the problem with 'Wichita'. The clone 'Cheyenne', also one of those originally recommended for California, has only limited value because of its small nut size. Other promising clones emerging from this study are all Type II: 'Mohawk', 'Kiowa', 'Shoshoni', 'Choctaw', 41-19-20, 42-20-23, 53-9-100, 53-9-203, and 55-11-11. These clones have acceptable nut quality, have shown minimal alternate bearing to date, and are precocious. None of the Type I clones evaluated, other than 'Western Schley', appear acceptable for western

conditions based on the quality standards used.

Suitable pecan clones will be needed if the industry is to continue to expand in California. The currently grown 'Wichita', 'Cheyenne', and 'Western Schley' have limitations that may be overcome as additional clones are evaluated and become available. The availability of more appropriate clones may also make it possible to grow the crop in other areas, in addition to the southern San Joaquin Valley. To be successful, the potential grower should consider the pecan clone's leaf and harvest date, kernel quality, nut size, and its tendency to bear early, heavy, regular crops.

G. Steven Sibbett is Farm Advisor, University of California Cooperative Extension, Tulare County; Tommy E. Thompson is Research Geneticist, USDA W.R. Poage Pecan Field Station, Brownwood, Texas; and Nick Troiani is Superintendent, Lagomarsino Farms, Tulare, California.