COMPARATIVE LEAF CHARACTERISTICS OF SIX PECAN CULTIVARS

Carya illinoensis Koch

By

Leonard K. Gould

B. S. Colorado State University

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Approved by:

R W Campbell

Major Professor

TABLE OF CONTENTS

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LIST OF TABLES

INTRODUCTION

The pecan is an important horticultural crop in the United States. It is known for its excellent flavor in bakery goods or eating as a nut meat. There are numerous cultivars with varying degrees of nut yield and quality.

Pecans are variable in their habits of bearing. Heavy crops are most frequently followed by light crops the following year. Some cultivars are more regular bearers than others.

The characteristic of alternate bearing is a disadvantage to the commercial pecan grower. Several interrelated factors are credited to be the cause of biennial bearing; rather than one factor, according to Crane (3).

The foliage and fruit are susceptible to several insect and disease organisms. These organisms reduce the leaf area where photosynthates are produced. The quantity and quality of fruit are also affected. Proper nut development requires a certain period of photosynthetic activity as reported by Crane (3).

Pecan cultivars are dissimilar in leaflet number, size and shape. Leaf and tree characters have been used to identify cultivars. More information about pecan leaves might also serve to identify or classify pecan cultivars.

Leaves are essential in producing food for tree growth and nut development. More information about the amount of leaf area necessary

to maintain adequate growth and maximum fruit production would be of considerable value to commercial pecan producers.

Leaf-fruit ratios for high yield and quality have been determined for several fruit species, as reported by Weinberger (33), Heinicke (10), and Roberts (28). Basic studies of the physical characteristics of pecan leaves are needed to aid other researchers in leaf-fruit ratio determinations.

Objectives for this study were to: (1) explore the external characteristics of pecan foliage in an effort to gain knowledge concerning leaf characters of six pecan cultivars; (2) determine if there were significant differences in leaf area measurements between cultivars which would provide a foundation for basic area-yield studies; and (3) determine if a correlation exists between leaf shape and size and the shape and size of the nut.

REVIEW OF LITERATURE

Meader and Blake (22) found that the leaf characters of peaches that gave the most reliable information for variety identification were width-length ratios, base angles, apex angles and leaf conformation. Leaf width-length ratio was found the most reliable of all measurements. Further studies by Meader and Blake (23) indicated that larger leaf blades gave the most reliable data for leaf characters as a whole. They indicated that measureable leaf characteristics can be useful in peach variety identification when used in conjunction with other useful criteria.

According to Lapkins and Nash (16) when sampling from more than one location, variation among peach leaf characteristics increases. They also found in identification of peach varieties in nursery trees that a large deviation of individual observations from mean values was caused by location effect and interaction between seasons and locations.

Lott and Enzie (18) found significant difference in certain leaf characters in pecan. These differences would be useful in varietal identification. Ten characters provided major differences in the varieties tested. Leaf areas of the terminal pair of leaflets showed considerable difference between varieties. Leaf and leaflet petiole lengths showed significant differences between varieties with leaf petiole length having the most variation. In all varieties tested the area above the midrib of the leaflet was always greater than the area below the midrib. Varieties tested included at least one from each commercial producing region. In addition they reported that most leaflets were lanceolate in shape.

Reed and Davidson (27) indicate the genus Carya is characterized by variation in leaf and nut form. They reported that hickories easily hybridize which contributes to this variation. The compound leaf was found to have five to seventeen opposite leaflets. Hickory leaves and leaflets are longer and wider than that of pecan. The number of leaflets per leaf is less in the hickories. Some mature hickory leaves are pubescent underneath, according to Reed and Davidson (27).

Romberg (29) indicated that pubescence is pronounced on juvenile leaves but not on leaves of bearing branches. The difference is an identification of juvenility in pecan, a condition which is inherent and carried with the buds. He reports that branches from these buds do not bear because flower differentiation is inhibited.

Tydeman (32) found that leaf shape expressed as width-length ratio in percent by clonal races of *Malling* rootstocks, showed variation of 6 to 10.5 percent. Varieties grouped into three classes based on width-length as percent were found significantly different. Petiole leaf length ratio expressed as percent was also significant between classes.

Levering (17) reported that varietal differences occur due to leaf exposure to the sun, size and age of leaves. Form and growth of leaves varies differently to sun and shade exposure.

Anderson (1) found that shade leaves developed earlier, grew larger and had larger areas than sun leaves.

Temperature may be a factor in the time of leaf development, according to Anderson (1). He concluded that the optimum temperature

for leaf development was found to be 76.8° F. and high temperature inhibits cell division in the leaf primordia and extra high temperature decreases rate of growth.

Sun leaves were reported to be darker, heavier and thicker for herbs, shrubs and deciduous trees by Talbert and Holch (31). Over half of the shade leaf perimeters were greater than on sun leaves. They found 78 percent of the shade leaves had greater leaf area and over 56 percent had longer petioles. Leaf margins were more pronounced on sun leaves and leaf shape influences degree of variation between sun and shade leaves of the same plant according to Talbert and Holch (31).

Dark green pecan leaves showed an increase in photosynthetic activity over light green leaves, according to Lutz and Hardy (20). They reported foliage should be present six months or more for optimum tree growth and fruit development. In addition they concluded that healthy leaves function and remain longer than diseased or less healthy leaves.

Loustalot (19) concluded that photosynthesis is primarily affected by changes in light intensity and transpiration rate is affected more by changes in temperature and relative humidity. Transpiration rate decreased with a decrease in temperature and an increase in relative humidity.

Kelley (12) observed in deciduous fruits that broad leaves transpired more rapidly than long, narrow leaves per square inch of leaf surface.

Pickett and Kenworthy (26) reported that correlation between ratio of internal exposed surface to external surface of three apple varieties and their photosynthetic activity is significant. They concluded that exposed internal leaf surface is more important than chlorophyll content as a factor partially regulating photosynthetic activity.

Photosynthetic activity decreases as the angle of incidence of light increases was reported by Kriedman et al (15).

According to Christopher (2) on a day favorable for photosynthetic activity, carbon dioxide assimilation on east facing leaves was 20 percent greater than on west facing leaves.

Heinicke (10) reported the carbon dioxide assimilation rate of leaves during cloudy days is about 25 percent the rate on clear days.

Numerous workers (11, 14, 30, 21, 34, 24, 33) have reported on leaf area-sunlight relationships, leaf area-fruit production correlation, number of leaves per fruit and correlation of fruit quality to leaf area as to the importance of foliage in the production of various fruit crops. A good increase in apple volume with a leaf area per fruit increase to 500 cm.^{2} was reported by Haller and Magness (8). However, heavy fruit production reduced blossom bud formation the following year.

Pickett (25) reported a high correlation existed between leaves per fruit and fruit size in apples. Leaf-fruit ratios of 30 and 40:1 with 50 to 90 square inches of area could be considered optimum for most cultivars. Previously Haller and Magness (7) found the volume and weight of apples directly correlated with leaf area to a certain level.

Dodge (4) found an insufficient number of pecan leaves per fruit resulted in poor nut filling and poor flower bud development. The study showed a minimum of 10 leaves per nut was needed for well filled nuts.

Heinicke (9) reported a large early leaf area enhances regular bearing in many apple varieties. Also, the rate of photosynthesis of large dark green leaves is greater than pale green leaves and carbohydrate reserves are increased early in the season. Photosynthesis should continue into the fall to be effective in eliminating alternate bearing, according to Heinicke (9).

Crane (3) reported that under average conditions, crop size and filling of pecan nuts is directly related to leaf area and time the foliage remains on the tree.

Finch (5) reported that highly vegetative pecan trees resulted in poor nut filling but an increase in pistillate blossoms the following spring. The increased nitrogen content in highly vegetative trees may have a reducing effect on carbohydrate storage. Finch and Van Horn (6) concluded that reduced soil moisture decreases nitrogen content in pecan leaves and enhances carbohydrate storage in the tree. They also reported that pecan varieties that metabolized less nitrogen and stored more carbohydrates generally produce well filled nuts. Lower vegetativeness was found to favor nut filling and high vegetativeness favors flower development.

MATERIALS AND METHODS

Four hardy northern pecans, Giles (GI), Greenriver (GR), Major (M) and Peruque (P) and two southern pecan cultivars, GrayTex (GX) and Western Schley (WS), from the W.F. Thielenhaus orchard north of Fredonia, Kansas, were selected for leaf studies. Four trees of each cultivar were selected for replicate sampling. All sample trees had borne fruit at least one year. The trees were located on gentle to moderate rolling pasture land and were growing in a Bates loam soil (13). Leaf samples were taken on June 27, July 4 and 5, 1967.

Twelve leaf samples each were taken from both the northeast and southwest quarters of each tree. Leaves were picked from the mid-portion of the current seasons growth and put in polyethylene bags. Damp paper towelling was put in the bags to reduce wilting. The sample bags were placed in refrigerated storage upon return to Kansas State University.

Leaf prints were made of all samples. A plywood board 24 inches wide and 50 inches long was covered with a large terry cloth towel. Each leaf sample was put on chemically treated light sensitive paper which was placed on the board. A piece of one-quarter inch plate glass was placed on top of the leaves to press them firmly on the paper. The glass was covered with a piece of heavy paper and placed outside to be exposed to the sunlight. The paper was removed and exposure time was recorded in seconds.

Several trials were run to determine the optimum exposure time in direct sunlight. When the sun's rays were direct, required exposure

time was reduced. Between 11:00 a.m. and 3:00 p.m. 20 to 30 seconds of exposure was best. From 3:00 p.m. to 6:00 p.m. exposure time increased from 30 to 45 seconds.

This method was used for two cultivars and was satisfactory only in full sunlight. Cloud cover reduced the quality of the print and control of exposure time.

In order to have control of exposure time, artificial light was used on samples of the four remaining cultivars. Two 500 watt reflector coated flood lamps were mounted on rods extending from metal ring stands. The lamps were positioned 20 inches apart, 18 to 20 inches above the plateglass. This elevation and distance between the flood lamps provided sufficient light intensity and a minimum amount of shadows for good prints. The best exposure time was 40 seconds.

After exposure, the paper was placed in a chromatagraphic chamber containing three 500 milliliter beakers about half full of 28 percent ammonium hydroxide solution. Blue prints of the leaves required one to four minutes of exposure time depending on the strength of the fumes from the solution.

All measurements were made from the blue prints of the leaf samples. Leaf area measurements were made with a compensating polar planimeter. Two readings were taken on each leaflet with the average being recorded. If two readings were over fifty points apart, another reading was taken and the average of the three was recorded. The planimeter could be read to the nearest one-hundredth of a square inch.

Some leaflets were partially damaged. Area measurements were made as if the total leaf was there.

Base angle measurements were made with a protractor and straight-edge. A mark was made on the leaf margin one-half inch from the point of intersection of the petiole and leaflet blade. The protractor base was placed over the leaf-petiole intersect point and lower mark. A straightedge was placed from intersect point to upper mark and the angle was read.

Apex angles were measured by the same procedure except the distance from leaflet tip to upper and lower margin marks were one inch.

Both measurements were made only on the distal pair of leaflets of each sample.

Leaf measurements include total length, petiole length and paired leaflet distribution along the rachis.

Distal leaflet pair measurements, petiole length and width-length ratios were expressed in percent. An engineers scale of 20 units to the inch was used.

Twenty-four nuts from each of the six cultivars were measured for total length and average diameter with a pair of dividers and a rule in tenths of inches. Minimum and maximum diameters were averaged to get the average diameter.

Diameter-length ratios were expressed in percent.

RESULTS

Significant differences in all comparisons of leaf characteristics were found among six different pecan cultivars at the five percent level.

Total mean leaf area ranged from 673 square inches for Western Schley to 1,046 square inches for Major. Variations of leaf area between quadrants were minor for five of the six cultivars, ranging from 10 square inches per leaf for Peruque to 19 square inches per leaf for Western Schley. Major had a difference of mean leaf area between quadrants of 76 square inches. Northern cultivar quadrant leaf areas were greater for all cultivars but not to the extent of being statistically significant. Leaf area measurements and statistical results are shown in Table I.

Comparison of terminal paired leaflets area to total leaf area in percent resulted in a different cultivar order from that found for leaf area values. Three cultivars, Giles, Greenriver and Major had larger terminal leaflet area values in the southern quadrant (Table II).

The results of Table III, a comparison of the number of leaflets per leaf, indicated there was not a direct relationship of leaflet number to leaf area. Greenriver had the least number of leaflets but recorded the second greatest leaf area. GraTex and Western Schley had the most leaflets but were among the lowest in leaf area.

Differences in leaf lengths among the cultivars ranged from 10.8 inches for Western Schley to 13.25 inches for Major. Results indicated that leaves of the four northern cultivars were larger than those of Western Schley but not GraTex (Table IV).

Leaf petiole mean lengths from the different cultivars ranged from 1.8 inches to 2.3 inches. The shortest and longest measurements found were from the southern cultivars, Western Schley and GraTex, respectively (Table V). Peruque tied with GraTex for the longest leaf petiole.

Tables VI through IX record the distance between paired leaflets on the rachis. Four sections were measured and compared. All cultivars showed consecutive increasing distances for the first three sections. A similar trend existed with all cultivars for section four except Greenriver which showed only a slight decrease in distance between leaflets from the southern quadrant but a considerable reduction for those from the northern quadrant. Most of the distance measurements were higher in the northern quadrants. Greenriver had the greatest distance for the first three sections followed by Giles and GraTex. The latter two also had measurements in section four that were very close to that of Major.

Major recorded the longest single distance occurring in section four which is the section nearest the terminal leaflet. In all cultivars the shortest distances were recorded for the first section.

In Table X, terminal paired leaflet petiole lengths were the shortest for Western Schley. A similar result was recorded in Table V for the leaf petiole length. Peruque had the longest leaflet petiole length. A similar position was held in leaf petiole length comparisons along with GraTex in Table V.

Results of the width-length ratio of terminal paired leaflets are shown in Table XI. Significant differences were found among the

different cultivars and also quadrants of cultivars at the five percent level. Southern quadrants produced greater width-length ratios in all cultivars except Greenriver and Western Schley. Greenriver had the largest width-length ratio value and Giles the smallest.

Other features considered for comparisons were base angles and apex angles of terminal paired leaflets. Results are shown in Tables XII and XIII. Differences in base angles were significant among the various cultivars and leaflet position among cultivars at the five percent level. Greenriver recorded the largest base angle and Giles had the smallest angle measurement. Leaves from southern quadrants exceeded those from northern quadrants in angle size in all cultivars except Major and Western Schley. The leaflet positioned on the right of the rachis had the greatest base angle value among all cultivars.

Observations of apex angles for the six cultivars showed significant differences among cultivars at the five percent level (Table XIII). A similar result in ranking of cultivars was found in apex angle comparison as found for the base angle. The order of cultivars of largest angle to smallest was the same for both angle comparisons. Southern quadrant apex angles were greater for all cultivars. Greenriver had the largest apex angle and Giles the smallest.

A positive correlation was found in the ratio of leaflet width to leaflet length at the one percent level among all the cultivars.

In the correlation of nut width to nut length only Greenriver was positive at the five percent level.

Correlation results are shown in Tables XIV and XV.

Section A, was used as a measure for total leaf area.

Section B, was used as a measure for the ratio of terminal paired leaflet area to total leaf area.

Section C, was used as a measure of the number of leaflets per leaf.

Section D, was used as a measure of total leaf length.

Section E, was used as a measure of leaf petiole length.

Section F_1 - F_4, was used as a measure of paired leaflet distribution along the rachis, section one through section four.

Section G, was used as a measure of terminal paired leaflet petiole lengths.

Section H, was used as a measure of the width-length ratio of terminal paired leaflets.

Section I, was used as a measure of the base angles of terminal paired leaflets.

Section J, was used as a measure of the apex angles of terminal paired leaflets.

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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Figure I Compound leaf of the Pecan showing location of sampling for various studies

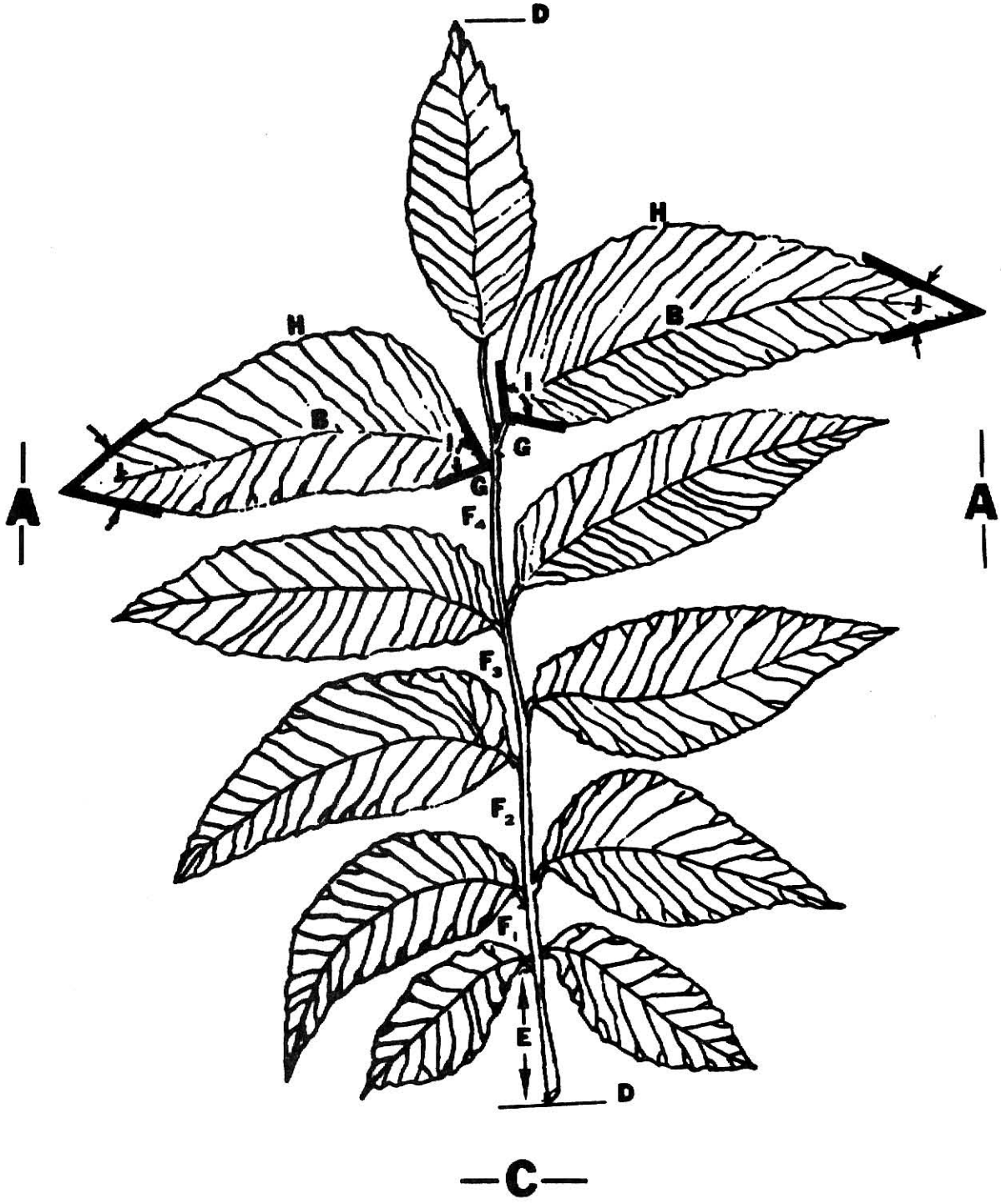

TABLE I

Leaf area (mean values) for six pecan cultivars in square inches

Analysis of Variance				
Source	D.F.	Mean Square	F	LSD.05
Cultivars	5	45,169.60	8.41*	74.28
N Quadrants	1	3,560.00	0.66	
S Cultivars and Quadrants	5	2,143.60	0.40	
Error	36	5,373.75		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	375	358	527	512	561	485	500	490	427	415	345	327

Array Means

(S)WS	(N)WS	(S)GI	(N)GI	(S)GX	(N)GX	(S)M	(S)P	(N)P	(S)GR	(N)GR	(N)M
327	346	358	375	415	427	485	490	500	512	527	561

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE II

A comparison of terminal paired leaflets area to total leaf area (mean values) for six pecan cultivars in percent.

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	105.60	19.03*	2.39
Quadrants N S	1	2.62	0.47	
Cultivars and Quadrants	5	2.18	0.39	
Error	36	5.55		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	22.1	23.0	28.3	30.5	23.4	24.2	19.7	19.1	23.3	20.8	20.2	20.0

Array Means

(S)P	(N)P	(S)WS	(N)WS	(S)GX	(N)GX	(N)GI	(S)GI	(N)M	(S)M	(N)GR	(S)GR
19.1	19.7	20.0	20.2	20.8	21.3	22.1	23.0	23.4	24.2	28.3	30.5

*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE III

A comparison of the number of leaflets per leaf (mean values) for six pecan cultivars.

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	13.09	29.75*	0.69
N Quadrants	1	0.27	0.50	
S Cultivars and Quadrants	5	0.09	0.20	
Error	36	0.44		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrant:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	10.6	10.1	9.6	9.3	11.7	11.6	13.0	12.8	11.3	11.4	12.4	12.4

Array Means

(S)GR	(N)GR	(S)GI	(N)GI	(N)GX	(S)GX	(S)M	(N)M	(S)WS	(N)WS	(S)P	(N)P
9.3	9.6	10.1	10.6	11.3	11.4	11.6	11.7	12.4	12.4	12.8	13.0

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE IV

A comparison of total leaf length (mean values)
for six pecan cultivars in inches.

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	6.14	7.40*	0.91
N Quadrants S	1	2.98	3.60	
Cultivars and Quadrants	5	0.09	0.11	
Error	36	0.83		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	12.6	12.1	12.9	12.6	13.7	12.8	12.9	12.6	13.3	12.6	11.0	10.6

Array Means

(S)WS	(N)WS	(S)GI	(N)GI	(S)GR	(S)P	(S)GX	(S)M	(N)GR	(N)P	(N)GX	(N)M
10.6	11.0	12.1	12.6	12.6	12.6	12.6	12.8	12.9	12.9	13.3	13.7

*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE V

A comparison of leaf petiole length (mean values) for six pecan cultivars in inches.

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	0.34	6.80*	0.22
N Quadrants S	1	0.01	0.20	
Cultivars and Quadrants	5	0.02	0.40	
Error	36	0.05		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	2.0	2.1	2.2	2.1	2.1	1.9	2.3	2.3	2.3	2.3	1.8	1.8

Array Means

(N)WS	(S)WS	(S)M	(N)GI	(S)GI	(S)GR	(N)M	(N)GR	(N)P	(S)P	(N)GX	(S)GX
1.8	1.8	1.9	2.0	2.1	2.1	2.1	2.2	2.3	2.3	2.3	2.3

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE VI

A comparison of leaflet pair distribution on the rachis of six pecan cultivars, section one nearest to the base of the leaf, in inches (mean values).

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	0.183	10.17*	0.14
N Quadrants S	1	0.003	0.17	
Cultivars and Quadrants	5	0.004	0.22	
Error	36	0.018		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western	Schley
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	1.02	1.06	1.10	1.07	0.88	0.80	0.77	0.80	1.03	1.00	0.73	0.72

Array Means

(S)WS	(N)WS	(N)P	(S)P	(S)M	(N)M	(S)GX	(N)GI	(N)GX	(S)GI	(S)GR	(N)GR
0.72	0.73	0.77	0.80	0.80	0.88	1.00	1.02	1.03	1.06	1.07	1.10

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE VII

A comparison of leaflet pair distribution on the rachis of six pecan cultivars, section two away from the base of the leaf, in inches (mean values).

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	0.289	13.14*	0.15
N Quadrants S	1	0.022	1.00	
Cultivars and Quadrants	5	0.004	0.18	
Error	36	0.022		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	1.40	1.40	1.46	1.45	1.24	1.14	1.11	1.09	1.38	1.27	0.96	0.95

Array Means

(S)WS	(N)WS	(S)P	(N)P	(S)M	(N)M	(S)GX	(N)GX	(N)GI	(S)GI	(S)GR	(N)GR
0.95	0.96	1.09	1.11	1.14	1.24	1.27	1.38	1.40	1.40	1.45	1.46

*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE VIII

A comparison of leaflet pair distribution on the rachis of six pecan cultivars, section three away from the base of the leaf, in inches (mean values).

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	0.363	20.16*	0.14
N Quadrants S	1	0.038	2.11	
Cultivars and Quadrants	5	0.003	0.17	
Error	36	0.018		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	1.59	1.57	1.59	1.59	1.44	1.36	1.23	1.16	1.52	1.39	1.09	1.03

Array Means

(S)WS	(N)WS	(S)P	(N)P	(S)M	(S)GX	(N)M	(N)GX	(S)GI	(N)GI	(N)GR	(S)GR
1.03	1.09	1.16	1.23	1.36	1.39	1.44	1.52	1.57	1.59	1.59	1.59

*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE IX

A comparison of leaflet pair distribution on the rachis of six pecan cultivars, section four away from the base of the leaf, in inches (mean values).

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars N	5	0.231	3.08*	0.28
Quadrants S	1	0.001	0.013	
Cultivars and Quadrants	5	0.040	0.04	
Error	36	0.075		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrant:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	1.60	1.57	1.22	1.49	1.61	1.52	1.39	1.28	1.58	1.46	1.17	1.15

Array Means

(S)WS	(N)WS	(N)GR	(S)P	(N)P	(S)GX	(S)GR	(S)M	(S)GI	(N)GX	(N)GI	(N)M
1.15	1.17	1.22	1.28	1.39	1.46	1.49	1.52	1.57	1.58	1.60	1.61

*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE X

A comparison of the petiole lengths of terminal paired leaflets for six pecan cultivars (mean values) in inches.

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	.0114	14.07*	0.028
N Quadrants	1	.0030	3.70	
S L Petioles	1	.0016	1.97	
R Cultivars and Quadrants	5	.0002	0.25	
Cultivars and Petioles	5	.0001	0.12	
Quadrants and Petioles	1	.00002	0.02	
Cultivars, Quadrants and Petioles	5	.00005	0.06	
Error	72	.00081		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Means	.207	.205	.200	.197	.187	.171	.227	.211	.197	.184	.150	.135

TABLE X (CONCL.)

Array Means

(S)WS	(N)WS	(S)M	(S)GX	(N)M	(N)GX	(S)GR	(N)GR	(S)GI	(N)GI	(S)P	(N)P
.135	.150	.171	.184	.187	.197	.197	.200	.205	.207	.211	.227

\# underlines: (S)WS–(N)WS; (N)WS–(S)M; (S)M–(S)GX; (S)GX–(N)M; (N)M–(N)GX; (N)GX–(S)GR; (S)GR–(N)GR; (N)GR–(S)GI; (S)GI–(N)GI; (N)GI–(S)P; (S)P–(N)P

*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE XI

A comparison of the width-length ratio of terminal paired leaflets for six pecan cultivars (mean values) expressed in percent.

Analysis of Variance				
Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	85.40	45.88*	1.35
N Quadrants S L	1	12.40	6.67*	
Leaflets R	1	1.67	0.90	
Cultivars and Quadrants	5	1.90	1.02	
Cultivars and Leaflets	5	0.51	0.27	
Quadrants and Leaflets	1	0.09	0.05	
Cultivars, Quadrants and Leaflets	5	0.23	0.12	
Error	72	1.86		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	24.09	26.08	31.34	31.28	28.30	28.82	25.78	26.61	25.92	26.53	27.76	26.17

TABLE XI (CONCL.)

Array Means

(N)GI	(N)P	(N)GX	(S)GI	(S)WS	(S)GX	(S)P	(N)WS	(N)M	(S)M	(S)GR	(N)GR
24.09	25.78	25.92	26.08	26.17	26.53	26.61	27.76	28.30	28.82	31.28	31.34

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE XII

A comparison of the base angles of terminal paired leaflets for six pecan cultivars (mean values) expressed in degrees.

Analysis of Variance

Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	.1744	96.89*	4.2
Quadrants N S L	1	.0040	2.22	
Leaflet R	1	.0135	7.50*	
Cultivars and Quadrants	5	.0021	1.17	
Cultivars and Leaflet	5	.0003	0.17	
Quadrants and Leaflet	1	.0001	0.06	
Cultivars, Quadrants and Leaflet	5	.0001	0.06	
Error	72	.0018		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrant:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	59.2	61.5	85.7	89.4	84.0	82.6	66.6	68.9	65.5	68.2	72.4	70.6

TABLE XII (CONCL.)

Array Means

(N)GI	(S)GI	(N)GX	(N)P	(S)GX	(S)P	(S)WS	(N)WS	(J)M	(N)M	(N)GR	(S)GR
59.2	61.5	65.5	66.2	68.2	68.9	70.6	72.4	82.6	84.0	85.7	89.4

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Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Leaflet:	L	R	L	R	L	R	L	R	L	R	L	R

Array Means

(L)GI	(R)GR	(L)GX	(L)P	(R)GX	(R)P	(L)WS	(R)WS	(L)M	(R)M	(L)GR	(R)GR
59.2	61.5	65.9	66.4	67.9	69.1	70.0	73.0	82.9	83.7	85.9	89.2

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE XIII

A comparison of the apex angles of terminal paired leaflets for six pecan cultivars (mean values) expressed in degrees.

Analysis of Variance				
Source	D.F.	Mean Square	F	LSD .05
Cultivars	5	.01890	17.50*	3.3
N Quadrants S L	1	.00570	5.28	
Leaflet R	1	.00004	0.04	
Cultivars and Quadrants	5	.00035	0.32	
Cultivars and Leaflet	5	.00016	0.15	
Quadrants and Leaflet	1	.00001	0.01	
Cultivars, Quadrants and Leaflet	5	.00004	0.04	
Error	72	.00108		

Variety:	Giles		Greenriver		Major		Peruque		GraTex		Western Schley	
Quadrants:	N	S	N	S	N	S	N	S	N	S	N	S
Mean	26.7	29.6	36.6	38.6	31.2	31.7	29.0	29.5	28.0	30.0	30.4	31.7

TABLE XIII (CONCL.)

Array Means

(N)GI	(N)GX	(N)P	(S)P	(S)GI	(S)GX	(N)WS	(N)M	(S)M	(S)WS	(N)GR	(S)GR
26.7	28.0	29.0	29.5	29.6	30.0	30.4	31.2	31.7	31.7	36.6	38.6

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*F-test significant at .05 level.
#Means underlined are equal at .05 level.

TABLE XIV

Correlation of leaflet width to leaflet length;
48 observations per cultivar.

Cultivar	Mean	Variance	Std. Dev.	Std. Error	Correlation
Giles N	4.423	0.392	0.626	0.090	0.902**
Giles S	4.348	0.359	0.599	0.086	0.677**
Greenriver N	5.270	0.656	0.810	0.117	0.686**
Greenriver S	5.225	0.520	0.721	0.104	0.689**
Major N	5.177	0.216	0.464	0.067	0.651**
Major S	4.820	0.328	0.573	0.083	0.647**
Peruque N	4.843	0.664	0.815	0.118	0.819**
Peruque S	4.668	0.503	0.709	0.102	0.776**
GraTex N	4.477	0.397	0.630	0.091	0.805**
GraTex S	4.276	0.329	0.573	0.083	0.862**
W. Schley N	3.953	0.340	0.584	0.084	0.825**
W. Schley S	3.784	0.306	0.553	0.080	0.828**

**Indicates significance at 1% level.

TABLE XV

Correlation between nut width and nut length; 24 observations per cultivar.

Cultivar	Mean	Variance	Std. Dev.	Std. Error	Correlation
Giles	1.533	0.004	0.065	0.013	0.308
Greenriver	1.423	0.003	0.057	0.012	0.476*
Major	1.152	0.002	0.040	0.008	- 0.230
Peruque	1.218	0.004	0.065	0.013	0.163
GraTex	1.507	0.006	0.079	0.016	0.157
W. Schley	1.702	0.004	0.062	0.013	0.166

*Indicates significance at 5% level.

THIS BOOK CONTAINS NUMEROUS PICTURES THAT ARE ATTACHED TO DOCUMENTS CROOKED.

THIS IS AS RECEIVED FROM CUSTOMER.

Figure 2 Compound leaf of the Pecan cultivar, Giles

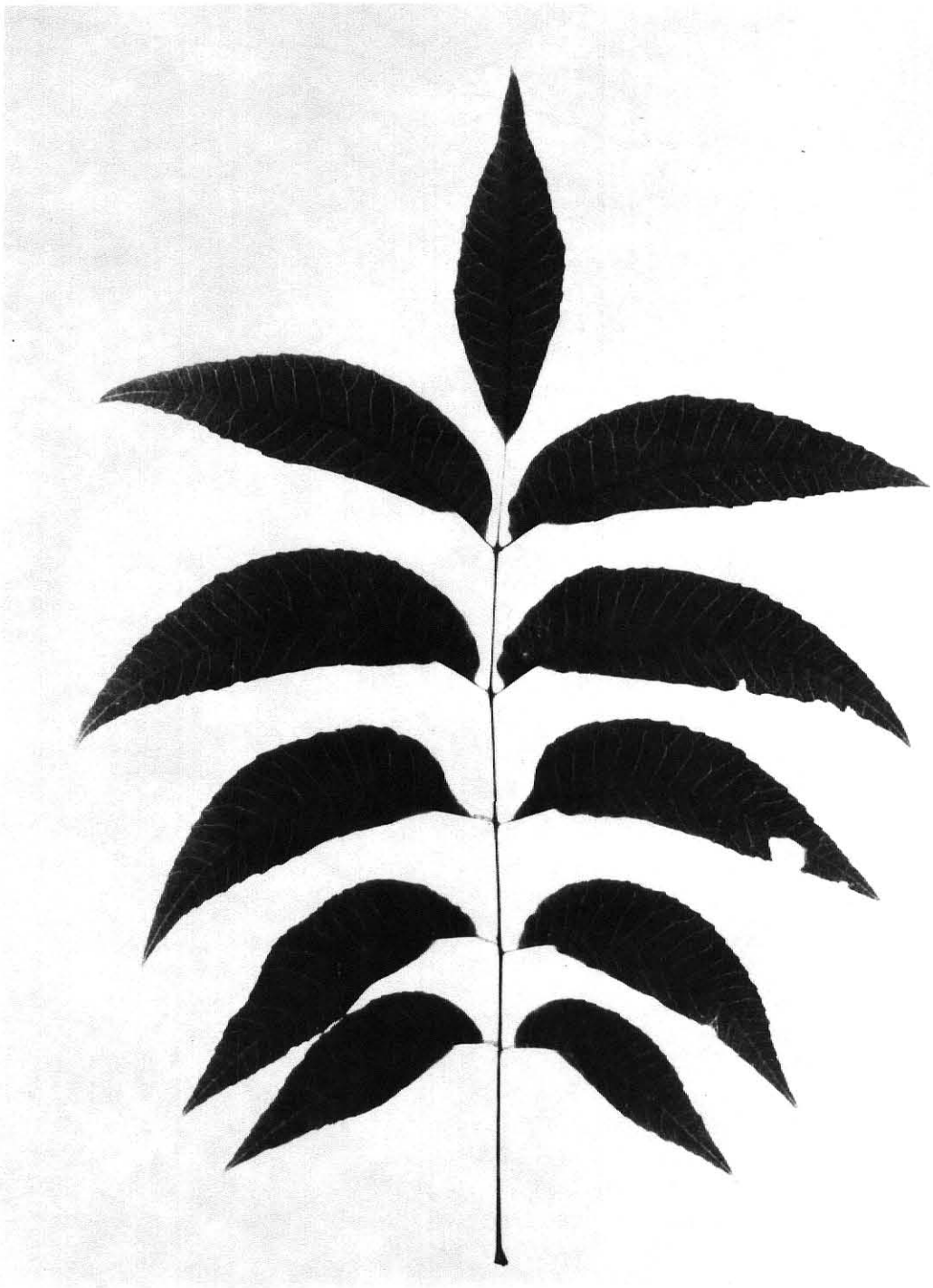


Figure 3 Compound leaf of the Pecan cultivar, Greenriver

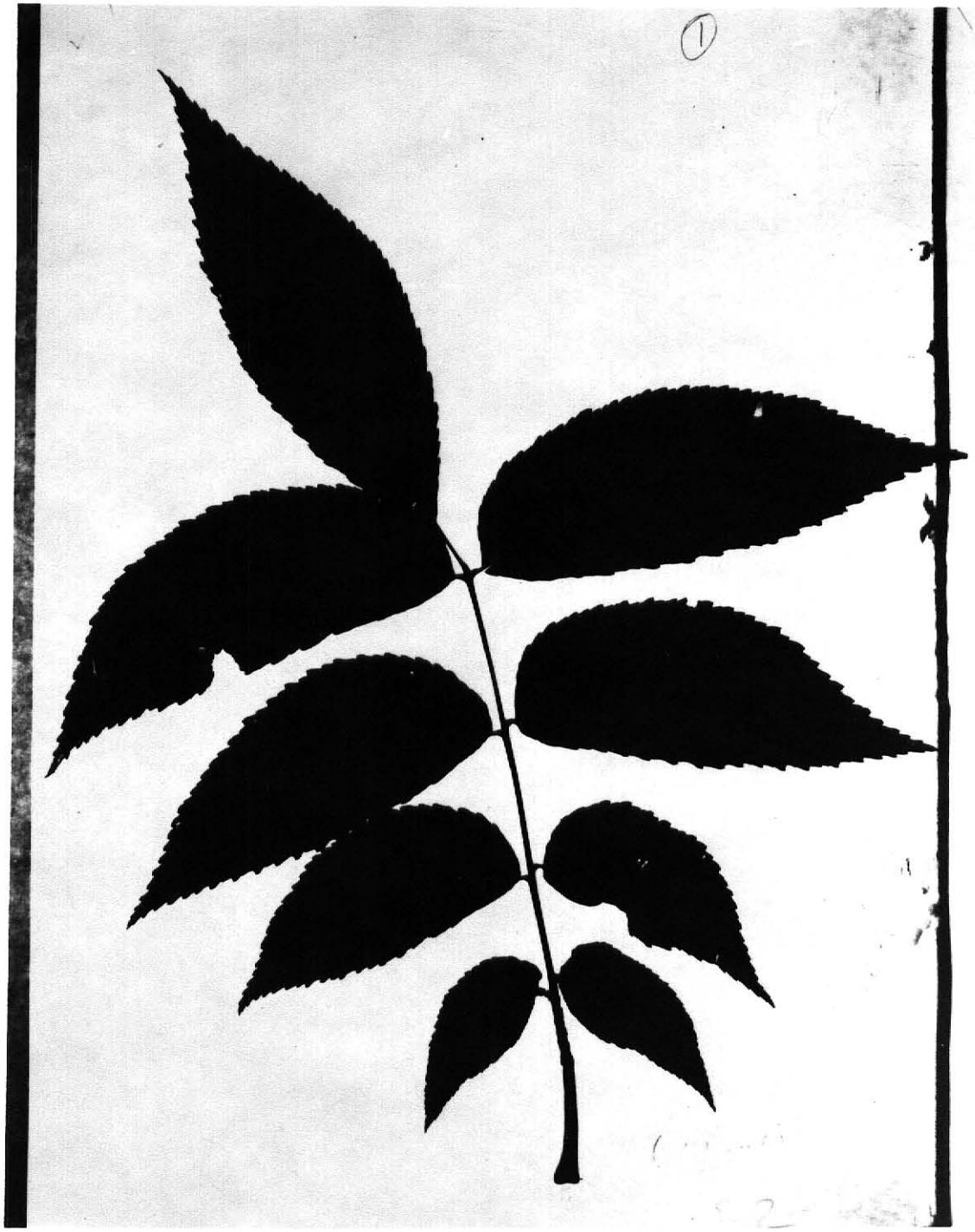


Figure 4 Compound leaf of the Pecan cultivar, Major

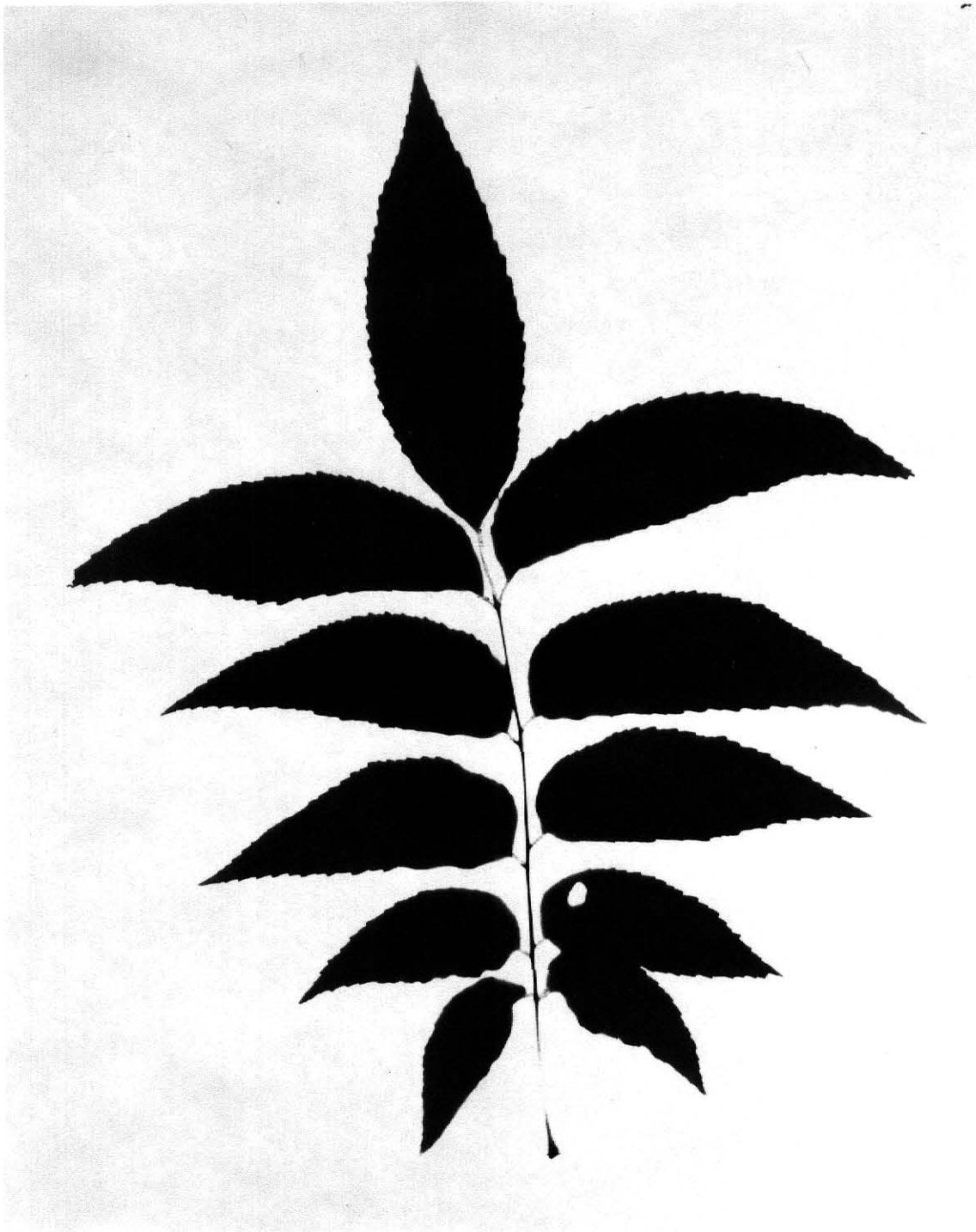


Figure 5 Compound leaf of the Pecan cultivar, Peruque

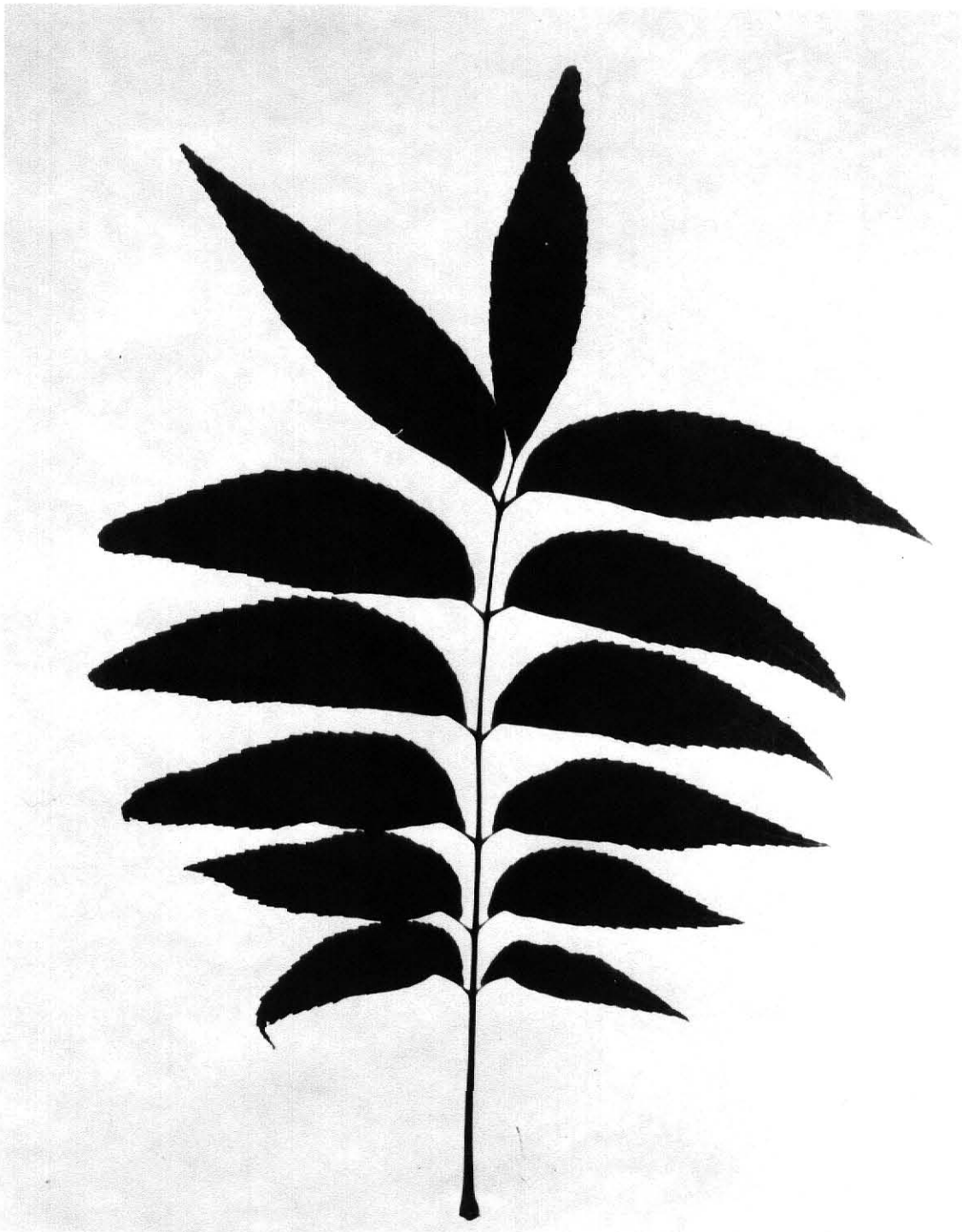


Figure 6 Compound leaf of the Pecan cultivar, GraTex

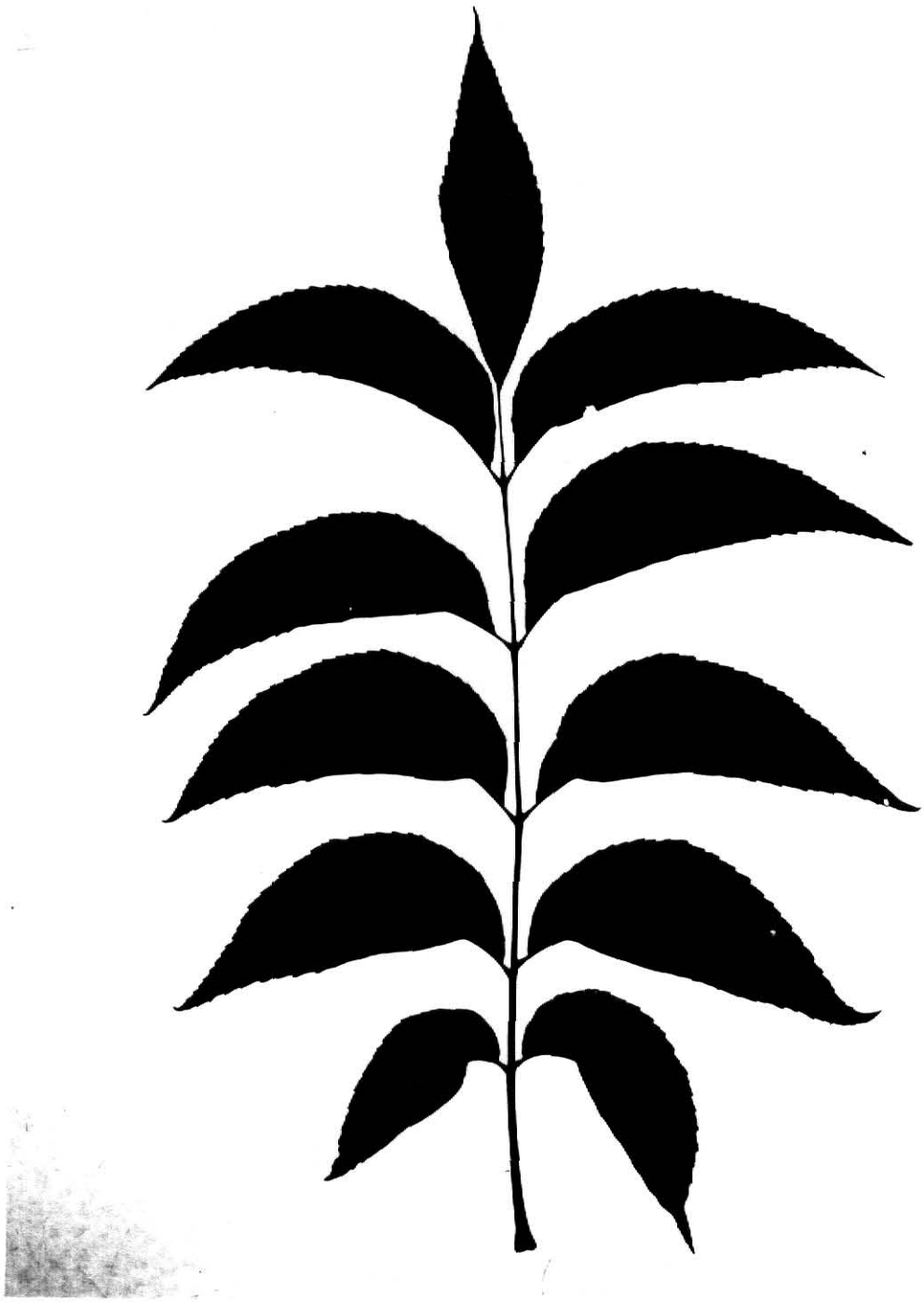
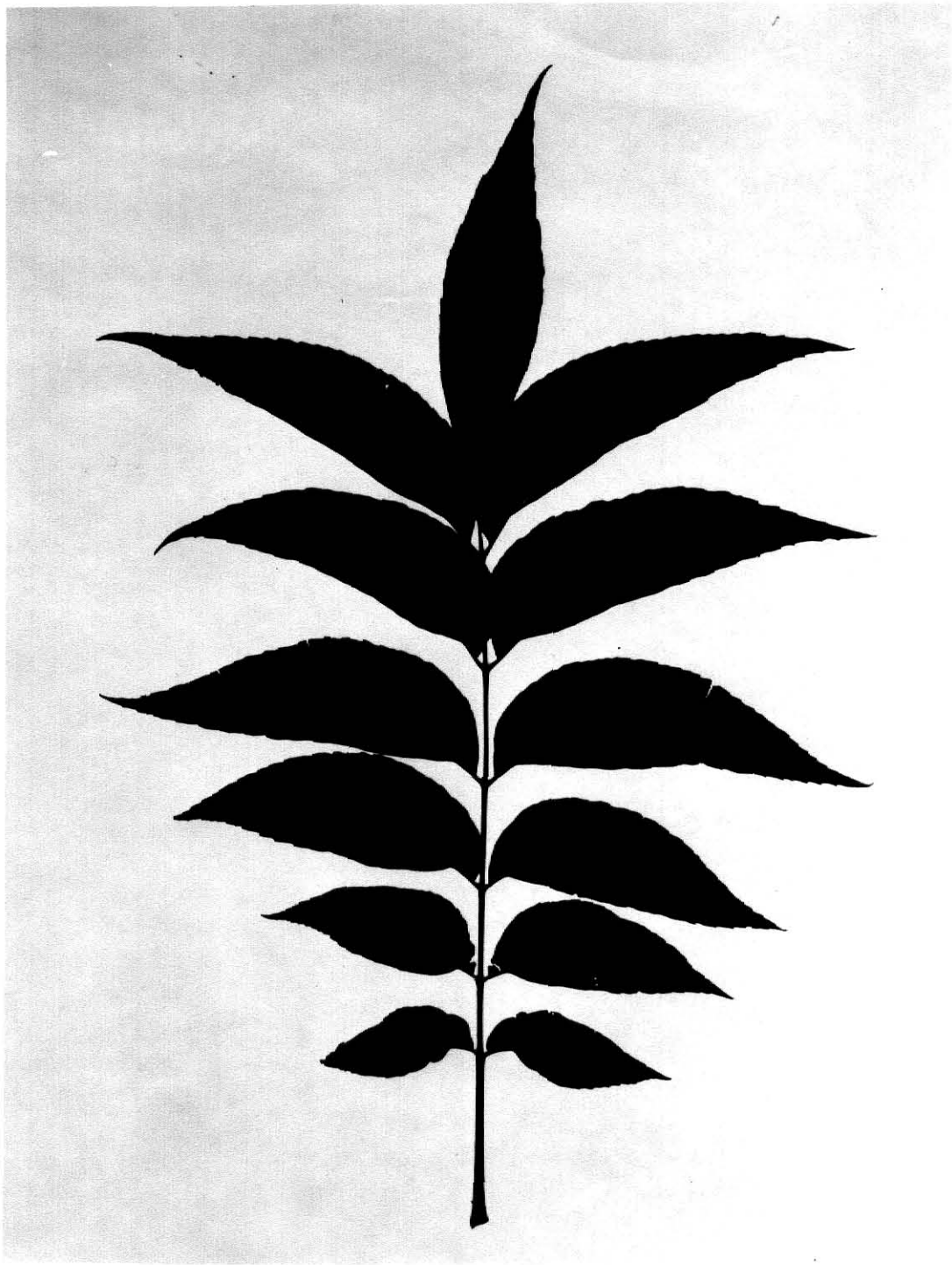


Figure 7 Compound leaf of the Pecan cultivar, Western Schley



DISCUSSION

Some significant differences in all comparisons of leaf characteristics were found among six different pecan cultivars.

Total leaf area comparisons indicated that northern pecan cultivars had a leaf area greater than that of the southern pecan cultivars. All cultivars from northern quadrants exhibited greater leaf area compared to those from southern quadrants but the increase was not great enough to be significant at the five percent level.

Three of the four northern cultivars had the highest percent of terminal leaflet area to the total leaf area and the leaflets from the southern quadrants were greater in terminal leaflet area than those from the northern quadrant areas for Giles, Greenriver and Major. Lott and Enzie (18) also found that there was a marked difference in leaflet area between pecan cultivars.

Peruque had the most leaflets-(13)-but only the third largest total leaf area. Greenriver had the fewest leaflets-(9)-but was second in total leaf area. The two southern cultivars had the next highest number of leaflets-(12, 11)-but were among the lowest in total leaf area.

Three of the four northern cultivars, Greenriver, Major and Peruque, recorded the greatest total leaf length. GraTex, a southern cultivar, had the second longest total leaf length. The four greatest lengths were recorded for leaves from the northern quadrants of each of the four cultivars.

Very little difference was found among the cultivars on leaf petiole length. Peruque and GraTex had the longest and identical leaf petiole lengths. Three of the four longest petioles were from the northern cultivars.

Distances between paired leaflets along the rachis for the first three sections were the longest among three of the four northern cultivars. Distance measurements for section four did not follow the cultivar order for the previous three sections. Greenriver, which had the longest distance between paired leaflets for the previous three sections, had next to the shortest distance in section four.

The northern cultivars recorded three of the four longest leaflet petiole lengths of the terminal paired leaflets. Lott and Enzie (18) recorded differences in length of leaflet petioles for most of the pecan cultivars. Petiole lengths from all northern quadrants exceeded that of the southern quadrants for each of the six cultivars.

No similarities of leaflet petiole lengths to their corresponding leaf lengths were observed other than that of the northern cultivars were generally longer than for southern cultivars.

Width-length ratio of terminal paired leaflets expressed in percent found Greenriver and Major, first and second, respectively, followed by Western Schley and GraTex. Four of the six cultivars recorded greater ratios in the southern quadrants over northern quadrants. The differences were great enough to be significant among quadrants at the five percent level.

Meader and Blake (23) found that leaf width-length ratios in peach varieties were generally in agreement.

Greenriver and Major recorded the largest angle at the base of terminal paired leaflets followed by Western Schley and GraTex. Four of the six cultivars recorded larger leaflet base angles in the southern quadrant.

The right leaflet had the greatest base angle among all cultivars. The order from largest to smallest base angle for the left leaflets were identical to that of the right leaflet for all cultivars and they were both significant at the five percent level.

The order of apex angle comparison among cultivars was very similar to that of the base angle order with Greenriver, Major, and Western Schley recording the largest angle in that order. Southern quadrant recordings of apex angles were greater than corresponding north quadrant values for all cultivars.

A correlation of terminal leaflet width to leaflet length indicated significance at both the five percent and one percent levels among all the cultivars. The correlation of nut width to nut length showed that Greenriver was the only cultivar to indicate significance at the five percent level.

SUMMARY

Physical studies were made on leaf and leaflet characteristics from six different pecan cultivars. Comparisons were made between total leaf area, terminal leaflets area to total leaf area in percent, number of leaflets per leaf, total leaf length, leaf petiole length, distance of paired leaflets along the rachis, petiole lengths of terminal paired leaflets, width-length ratio of terminal paired leaflets, base angles of terminal paired leaflets and apex angles of terminal paired leaflets expressed in degrees.

Significant differences were found among cultivars in all comparative studies made.

This study indicated that pecan cultivars originating in the same general geographic area of the United States showed about equal significant differences and similarities for both groups. In the eastern group, Major and Greenriver, similarities of leaf characters occurred in leaf area, total leaf lengths, leaf petiole length, petiole length of terminal paired leaflets and base angles of left and right terminal leaflets. The western group, Giles and Western Schley, showed similarities in measurements of leaf area, leaf petiole length, and width-length ratio of terminal paired leaflets.

Greenriver and Major, as a group, differed from Giles and Western Schley in all leaf characteristics except for leaflet distribution on the rachis. This was due to lack of uniformity among the cultivars for all four sections along the rachis.

A simple correlation of terminal paired leaflets width-length ratio indicated significance among cultivars at both the five percent and one percent levels. Significant differences were not found for a similar correlation between north and south quadrants among the cultivars. Only Greenriver showed a correlation at the five percent level between nut width and nut length among the cultivars.

Further studies to correlate the data from this study with yield data would be of great value in the determination of the most adaptable cultivar(s) for pecan producers of this area.

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COMPARATIVE LEAF CHARACTERISTICS OF SIX PECAN CULTIVARS

Carya illinoensis Koch

By

Leonard K. Gould

B. S. Colorado State University

Fort Collins, Colorado, 1956

AN ABSTRACT OF A MASTER'S THESIS

Submitted in partial fulfillment of the

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The purpose of this study was to determine if there are differences in leaf characteristics among six cultivars of Carya illinoensis Koch: Giles, GraTex, Greenriver, Major, Peruque, and Western Schley.

Leaf prints were made on chemically treated light sensitive paper. Two methods of obtaining prints were tried, exposure to sunlight and exposure to artificial light, after which prints were placed in a chromatagraphic chamber containing a solution of 28 percent ammonium hydroxide. Due to cloud interference with the sun's rays, print quality was inconsistent. Treatment by artificial light and ammonium hydroxide produced consistent quality prints.

Leaf samples were taken from nut-bearing trees growing in a Bates loam soil near Fredonia, Kansas. Ninety-six leaf samples were taken from four trees of each of six cultivars. Of the twenty-four leaf samples selected, twelve samples each came from the northern and southern quadrants of each tree.

Least significant difference (LSD) statistical analysis test at the five percent level were used to compare leaf area, terminal paired leaflet area to total leaf area, number of leaflets, leaf length, leaf petiole length, paired leaflet distribution along the rachis for four sections, terminal paired leaflet petiole lengths, width-length ratio of terminal paired leaflets, base angles of terminal paired leaflets, and apex angles of terminal paired leaflets.

In all comparative studies made, there were significant differences between cultivars. The side of the tree from which the leaf samples were

taken had no effect on the physical leaf characteristics except for terminal paired leaflets width-length ratio where southern quadrant values were significantly greater. This study indicated that pecan cultivars originating in the same general area of the United States showed about equal amount of similarities in leaf characteristics as differences. However, there were significant differences between cultivars that originated in different geographic areas of the United States.

Giles and Western Schley which originated in Kansas and Texas respectively showed physical leaf characteristics different from leaves of Greenriver and Major, native to Kentucky.

In the ratio of leaflet width to leaflet length, a stronger correlation was indicated by Giles and Western Schley than exhibited by Greenriver and Major.

The ratio of nut width to nut length indicated a positive significant correlation for Greenriver and a negative correlation for Major. Correlations recorded for Giles and Western Schley were positive but not enough to be significant at the five percent level.

Further studies would be of value in correlating the information obtained from this experiment with yield studies to determine the most adaptable cultivar(s) for pecan producers of this area.