Incidence of Scab and Foliage Condition on Pecan Cultivars Grown without Fungicide or Insecticide Sprays in a Humid Region

William D. Goff,[1]
Monte L. Nesbitt,[2] and
Cathy L. Browne[3]

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Summary. Fourteen pecan (*Carya illinoensis*) clones with desirable traits selected from preliminary screenings were evaluated for scab resistance, foliage condition and foliage retention. No fungicide or insecticide sprays were applied in order to increase pest and disease pressure and to better assess suitability of the selections for low input plantings. Most clones were equal to or better than 'Elliott', the resistant standard cultivar and were superior to 'Desirable', the susceptible standard cultivar, in scab incidence and foliage condition.

Pecan trees are frequently grown in small plantings around rural homes in the southeastern U.S. or in urban settings to provide shade, beauty, and nut production. In humid regions, unsprayed trees of most commercial pecan cultivars develop incidence of pests that severely limit both nut production and tree appearance (Goff et al., 1991). Therefore, most of the popular cultivars like 'Desirable' perform poorly, as trees are seldom sprayed in landscapes or small plantings due to cost or label restrictions. A large pecan tree must be sprayed with an airblast sprayer to obtain good coverage and the cost of these sprayers is not justified by the return from only a small-acreage planting. Commercial availability of custom sprayers who will travel to spray small plantings of pecans is very limited. As a consequence, there is a need for development of pecan trees with superior tolerance to pests to fill the niche of pecan trees that perform well in humid environments with little or no spraying.

The most serious nut pest is pecan scab (*Cladosporium caryigenum*) which often destroys the crop entirely on susceptible cultivars in humid regions when trees are unsprayed. Serious insect pests include yellow aphids (*Monellia caryella* and *Monelliopsis pecanis*) and the black pecan aphid (*Melanocallis caryaefoliae*) (Tedders, 1978). Currently available cultivars with excellent scab resistance all have serious limitations. 'Elliott', perhaps the best of available cultivars with outstanding scab resistance, produces small nuts, alternately bears severely, is quite susceptible to yellow aphids, and has very early budbreak making it prone to freeze damage (Sparks, 1992). 'Gloria Grande', another cultivar with excellent scab resistance, is extremely susceptible to the black pecan aphid and produces nuts of mediocre to very poor quality in south Alabama in our observations. Others like 'Curtis' and 'Candy' produce very small nuts of marginal quality (Sparks, 1992).

Cultivars previously thought to have excellent scab resistance, including 'Sumner', 'Melrose' and 'Pointe Coupee #2', have more recently exhibited susceptibility to scab at some locations (Goff et al., 1998). The scab fungus exists as numerous strains, some of which may attack a given clone while others will not (Converse, 1960; Turechek and Stevenson, 1998). At a given location, the absence of the strain attacking a test clone may falsely suggest resistance on a cultivar that is readily infected at another location where the virulent strain is present.

In an effort to identify pecan cultivars suitable to urban settings and unsprayed plantings in the southeastern U.S., we began selecting, prescreening, and evaluating pecan clones about 20 years ago. Clones were from a variety of sources: named cultivars, unreleased crosses from the USDA breeding program, native trees selected from humid locations and cultivar seedlings (Thompson and Young, 1985) which are common throughout the southeastern U.S. (Table 1). These cultivar seedlings are the offspring of improved cultivars and often come up in fencerows or fields from nuts carried there by water movement or by birds or squirrels. Another common source of cultivar seedlings is from nursery trees where the scion died after transplanting and the trees grew back from the rootstock thus being offspring of the seed stock source. Commonly, 'Curtis' and 'Elliott' were used in southeastern nurseries (Grauke and Thompson, 1995) so a great many offspring of these quite resistant parents can be found. The present study reports information on advanced clones

Table 1. Parentage (for controlled crosses) or state of origin for seedling selections included in this report.

Selection	Parentage or state of origin
Barton	Schley x Success
Buchel 1	Texas
Carter	Mississippi
Curtis	Florida
Desirable	(Success x Jewett)?
Elliott	Florida
Gafford	Alabama
Gloria Grande	South Carolina
Hughes	Mississippi
Jenkins	Mississippi
Stuart	Alabama
Syrup Mill	Alabama
USDA 82-17-680	Wichita open-pollinated
USDA 88-7-11	Osage x Pawnee

Department of Horticulture, Auburn University, Auburn, AL 36849.

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[1]Professor, Dept. of Horticulture, Auburn University, AL 36849.

[2]Horticulturist, Gulf Coast Regional Research and Extension Center of Auburn University, Fairhope, AL 36532.

[3]Research Assistant, Dept. of Horticulture, Auburn University, AL 36849.

Table 2. Incidence of stem scab on unsprayed pecan trees grafted in 1996 in Low Input Orchard, E.V. Smith Research Center, Tallassee, Ala.

	Stem scab lesions on worst 1 ft (30.5 cm) of shoot[y]					
Cultivar	1996	1997	1998	1999	2000	Avg
USDA 88-7-11	0.0 c[z]	0.0 b	0.0 b	0.0 c	0.0 a	0.0 d
Barton	0.0 c	0.0 b	0.0 b	0.0 c	0.0 a	0.0 d
Curtis	0.0 c	0.0 b	0.0 b	0.0 c	0.0 a	0.0 d
Buchel 1	0.3 c	0.0 b	0.0 b	0.0 c	0.0 a	0.7 d
Gafford	8.3 c	0.0 b	0.0 b	0.0 c	0.0 a	1.0 cd
Jenkins	1.3 c	13.3 b	0.0 b	0.0 c	0.0 a	2.5 cd
Hughes	28 bc	0.0 b	0.5 b	2.0 c	0.0 a	5.2 cd
Syrup Mill	2.0 c	0.0 b	10.0 b	25 c	0.0 a	6.2 cd
USDA 82-17-680	0.0 c	0.0 b	0.0 b	40 c	0.0 a	6.7 cd
Gloria Grande	40 bc	10.0 b	0.0 b	0.0 c	0.0 a	8.3 cd
Carter	0.0 c	0.0 b	0.0 b	40 c	0.0 a	10.3 cd
Elliott (resistant check)	100 b	0.0 b	0.0 b	0.0 c	0.0 a	16.7 c
Stuart	100 b	400 a	20 b	350 b	0.0 a	148 b
Desirable (susceptible check)	300 a	450 a	533 a	533 a	13.3 a	348 a

[z]Mean separation within columns by Duncan's multiple range test ($P \leq 0.05$).
[y]Scab on stems was recorded as the number of discernible lesions on the worst-affected 1 ft (30.5 cm) of shoot growth easily observable from the ground as we walked around the tree.

which have passed preliminary screening at multiple humid locations with no spraying, and also exhibited good nut quality, excellent pest resistance, and acceptable yields.

Materials and methods

Grafted trees of 'Cheyenne' and 'Desirable' growing on rootstocks of unknown origin were planted in 1991–92 at a spacing of 40 × 40 ft (12.2 m) at the E.V. Smith Research Center of Auburn University near Tallassee in central Alabama. In 1997, because emphasis changed to low input in the planting, the trees were regrafted to test selections exhibiting greater resistance than 'Desirable' or 'Cheyenne' using the inlay bark graft. There were four single-tree replications in a randomized complete block design.

Trees were fertilized, drip-irrigated, and treated with herbicides according to established recommendations (Goff et al., 1989), but received no sprays for control of diseases, insects, or mites. In early October of each season, trees in each planting were rated for incidence of scab and for foliage condition and retention. Scab on stems was recorded as the number of discernible lesions on the worst-affected 1 ft (30.5 cm) of shoot growth easily observable from the ground as we walked around the tree. Leaf scab was recorded as the percentage of leaf surface visibly affected by scab on the worst-affected easily observable leaflet on the tree. Nut scab, similarly, was rated as the percentage of nut shuck surface area affected on the worst-affected easily observable nut on the tree from ground level.

We arrived at the disease rating system we chose to use in this experiment following 20 years of assessing pecan cultivars in an attempt to draw conclusions which matched what was clearly known from widespread observations in thousands of acres of grower orchards over many years. These observations clearly establish that the susceptible standard we use, 'Desirable', is much more seriously affected by the disease than the resistant standard, 'Elliott'. Since our assessments are made under field conditions where incidence is sometimes low, we needed a system to magnify the differences among selections. We have often used more established methods such as the Horsfall-Barratt rating system (Horsfall and Barratt, 1945). When such systems are used, quite often 'Desirable' and 'Elliott', which clearly are not the same in susceptibility, frequently group together statistically when 25 randomly selected leaves are assessed, as the absence of disease on many leaves dilutes and masks the clear differences observed when we select the worst occurrence, that is the most diseased leaves or nuts we can see from the ground as we walk around the tree. Our goal is not to assess disease incidence as you might in a fungicide test, but to determine whether the selection has the genetic capacity to ward off the disease. We almost always achieve the desired result with this rating system on our standard cultivars where we already know the answer, i.e., 'Desirable' is more susceptible than 'Elliott'. With other methods, this known result is often missed.

Foliage condition was a visual rating, on a 1 to 10 scale where 10 = best, bright green healthy foliage free of damage from pests and 1 = worst, badly damage leaves that have not fallen from the tree. Foliage retention was a visual estimate of the percentage of original leaves for the season that still remained on the tree at the time of the rating.

Results and discussion

Table 2 indicates stem scab lesions observed for the 5-year period of 1996–2000 on the trees grafted in 1996. 'Stuart' and 'Desirable', standard cultivars included as susceptible controls, had higher incidence than any of the test selections. 'Elliott', the scab-resistant control, had an unusually high number of scab lesions in 1996, but no incidence in other years. Three selections, 'Barton', 'Curtis', and USDA 88-7-11 had no stem scab lesions in any of the 5 years. Leaf scab incidence (Table 3) was similar to stem scab incidence, with all test selections being generally low and significantly better than the susceptible controls.

Incidence of nut scab was only available on 11 of the 14 selections (Table 4), as no nuts were present at season-end on 'Desirable', 'Stuart', or 'Carter'. 'Desirable' nuts were present early in the 1999 and 2000 growing season, but the nuts were so badly infected by scab that they fell off before harvest, which indicates the futility of growing popular cultivars like 'Desir-

Table 3. Incidence of leaf scab on unsprayed pecan trees grafted in 1996 in Low Input Orchard, E.V. Smith Research Center, Tallassee, Ala.

	Leaf scab (% on worst leaflet)[y]					
Cultivar	1996	1997	1998	1999	2000	Avg
Barton	0.0 b[z]	0.0 c	0.0 b	0.0 c	0.0 b	0.0 d
Buchel 1	0.0 b	0.0 c	0.0 b	0.0 c	0.0 b	0.0 d
Elliott (resistant check)	0.0 b	0.0 c	0.0 b	0.0 c	0.0 b	0.0 d
Curtis	0.0 b	0.0 c	0.0 b	1.3 c	0.0 b	0.2 d
Gafford	2.5 b	0.0 c	0.0 b	0.0 c	0.0 b	0.2 d
USDA 88-7-11	1.3 b	0.0 c	0.0 b	0.0 c	0.0 b	0.2 d
Hughes	0.5 b	0.0 c	0.0 b	3.0 c	0.0 b	0.6 d
Syrup Mill	1.3 b	0.0 c	0.0 b	5.0 c	0.0 b	1.0 d
Jenkins	1.7 b	3.3 c	0.0 b	0.3 c	0.0 b	1.2 d
Gloria Grande	0.0 b	5.0 c	0.0 b	1.0 c	0.0 b	1.6 cd
Carter	0.0 b	2.5 c	0.0 b	10.0 c	0.0 b	3.5 cd
USDA 82-17-680	0.0 b	1.0 c	0.0 b	30 b	0.0 b	5.2 c
Stuart	0.0 b	50 b	0.0 b	40 b	0.0 b	18.3 b
Desirable (susceptible check)	40 a	75 a	43 a	73 a	43 a	52 a

[z]Mean separation within columns by Duncan's multiple range test ($P \leq 0.05$).
[y]Leaf scab was recorded as the percentage of leaf surface visibly affected by scab on the worst-affected easily observable leaflet on the tree.

able' for nut production in humid regions without fungicide applications. In 1999, only 'Curtis' had no nut scab lesions. 'Gloria Grande', Hughes, 'Syrup Mill', and USDA 82-17-680 had significantly greater nut scab in 1999 than did 'Elliott', the scab-resistant control. Environmental pressure similar to that which occurred in 1999 is required to make meaningful distinctions. Rainfall was low in 2000, causing all clones to appear equally resistant.

A great number of historical evaluations for scab have been made where pressure was low due to weather or fungicide application. Such evaluations led to false presumptions that selections had acceptable levels of scab resistance when in fact they did not. Examples of cultivars which some researchers and growers considered to have sufficient resistance to grow in the Southeast include 'Cheyenne' and 'Wichita', and 'Western' (Sparks, 1992). Once these were planted in monoculture, however, incidence even with a good spray program usually increased to the point that economical control was not obtained, and most orchards were subsequently cut down or topworked to more resistant selections (Sparks, 1992). A rigorous screening before release could quite possibly have prevented the widespread planting of and resulting losses from these clones. Similarly, sufficiently rigorous screening at multiple sites may identify clones like 'Sumner', 'Melrose', and 'Pointe Coupee #2', that have resistance at some, but not all locations and are not widely suitable to unsprayed plantings in the southeast, having scabbed badly in certain years at certain sites in our evaluations (Goff et al., 1998).

Some question whether any pecan clones are resistant to scab, or whether they are all escapes, initially lacking exposure to virulent strains, but eventually succumbing to the disease over time (Littrell and Bertrand, 1981). Once the strain is introduced or develops, it might then proliferate when the clone is grown in monoculture in orchards, thereby overcoming what was once perceived as resistance. The existence of cultivars like 'Elliott', released about 1925 (Sparks, 1992) and commonly grown in the southeastern U.S. with only minor scab incidence, is evidence that clones with quite useful and durable resistance may be found.

Foliage condition ratings (Table 5) indicate that all of the test selections had better foliage at season-end than did 'Desirable' or 'Stuart'. In the case of 'Desirable', which is highly susceptible to scab relative to the clones in these experiments, the low foliage condition ratings could be attributed to leaf scab incidence. In the case of 'Stuart', which is not as susceptible to leaf scab as 'Desirable' (Table 3), other foliage diseases as well as insect damage likely contributed to the poor foliage conditions at season-end. 'Stuart' is highly susceptible to yellow aphids and to

Table 4. Incidence of nut scab on unsprayed pecan trees grafted in 1996, in Low Input Orchard, E.V. Smith Research Center, Tallassee, Ala.

	Nut scab (% on worst nut)[y]		
Cultivar	1999	2000	Avg
USDA 88-7-11	NA	0.0 a	0.0 b
Buchel 1	NA	0.0 a	0.0 b
Curtis	0.0 c[z]	0.0 a	0.0 b
Gafford	2.5 c	0.0 a	1.1 b
Barton	9.0 c	0.0 a	2.3 b
Elliott (resistant check)	8.0 c	0.0 a	4.0 b
Jenkins	15 bc	0.0 a	5.2 b
Gloria Grande	50 a	0.0 a	12.5 ab
Hughes	30 ab	0.0 a	15.0 ab
Syrup Mill	35 ab	0.0 a	17.5 ab
USDA 82-17-680	50 a	0.0 a	25.0 a
Carter	NA	NA	NA
Stuart	NA	NA	NA
Desirable (susceptible check)	NA	NA[x]	NA

[z]Mean separation within columns by Duncan's multiple range test ($P \leq 0.05$).
[y]Nut scab was rated as the percentage of nut shuck surface area affected on the worst-affected easily observable nut on the tree from ground level.
[x]Nuts fell from tree prior to rating date due to excessive scab.

Table 5. Foliage retention on unsprayed pecan trees grafted in 1996 in Low Input Orchard, E.V. Smith Research Center, Tallassee, Ala.

	Foliage retention[z]					
Cultivar	1996	1997	1998	1999	2000	Avg
USDA 82-17-680	79 ab[y]	90 ab	93 a	90 a	95 a	89 a
Gloria Grande	82 a	80 b	93 a	90 a	93 a	87 a
Buchel 1	69 ab	92 a	88 a	90 a	92 a	86 a
Carter	50 abc	88 ab	90 a	90 a	90 a	86 a
Curtis	56 abc	84 ab	97 a	95 a	95 a	85 a
Hughes	55 abc	90 ab	98 a	92 a	91 a	84 a
Gafford	57 abc	91 a	88 a	91 a	85 ab	84 a
USDA 88-7-11	52 abc	88 ab	97 a	98 a	85 ab	84 a
Barton	52 abc	93 a	91 a	95 a	88 a	84 a
Syrup Mill	58 abc	89 ab	93 a	93 a	85 ab	83 a
Jenkins	40 abc	88 ab	97 a	90 a	93 a	80 a
Stuart	75 ab	65 c	90 a	70 b	90 a	78 a
Elliott (resistant check)	15 c	0 e	95 a	90 a	90 a	58 b
Desirable (susceptible check)	30 bc	18 d	60 b	37 c	73 b	49 b

[z]Foliage retention is a visual estimate of the percentage of leaves remaining on the tree in early October.
[y]Mean separation within columns by Duncan's multiple range test ($P < 0.05$).

accumulation of sooty mold (*Capnodium* spp.) (Sparks, 1992). The good foliage condition at season-end of most of the experimental clones over several years suggests that they likely are at least somewhat tolerant to other foliage diseases and to foliage-damaging insects such as aphids and mites. Pecan leaves damaged from pests often senesce and abscise prematurely (Gazaway et al., 1991).

'Desirable' had the worst foliage retention in all years, except 1996 and 1997 when it was better than 'Elliott' only (Table 6). 'Elliott', which has extremely early budbreak (Sparks, 1992), suffered cold damage shortly after grafting and the weakened shoots lost leaves early due to cold damage in 1996 and 1997 and not due to pests. 'Elliott' trees recovered from cold damage in 1998, 1999 and 2000, providing marked improvement in foliage retention. 'Stuart' trees also had significantly lower foliage retention than experimental clones in 1997 and 1999.

Foliage retention ratings may differ among cultivars for two broad reasons (Sparks, 1992). Some cultivars drop foliage prematurely due to nutrient drain from leaves by fruit (Sparks, 1977), or from other severe stresses like drought. Our report deals with young trees either not fruiting at all or just coming into production and unlikely to have sufficient fruit for fruiting-related stress, and other stresses seem unlikely causes. The other reason for premature defoliation is pest-related. An assortment of leaf diseases can cause defoliation (Gazaway et al., 1991). Also, pecans damaged by black pecan aphids and pecan leaf scorch mites (*Eotetranychus hicoriae*) fall prematurely (Tedders, 1978). Yellow aphid damage, if severe and especially when it is accompanied by sooty mold accumulation, may cause leaves to fall prematurely (Tedders, 1978). Foliage retention is critical in pecan production, as trees which defoliate prematurely have low carbohydrate reserves and nut production is poor in the following season (Sparks and Brack, 1972; Worley, 1971, 1979).

We consider low incidence of pecan scab and ability to withstand leaf-damaging pests as prerequisites for cultivar performance in the southeastern U.S. While the selections evaluated here have had at least preliminary indications of acceptable nut quality and yield, most need additional long-term research to document acceptability for release as cultivars.

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