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DISEASE ASSESSMENT AND UNIFORMITY IN RATING METHODS

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ABSTRACT

Disease assessments are routinely made by plant pathologists studying ways to improve disease control. Methods used in making these assessments vary according to the preference of individuals. The variation in assessment methods often makes using data from one location difficult in other locations where different methods are used. This is particularly evident when one reviews data packages put together by companies introducing new products. To further complicate the situation, estimates of disease impact on quality and/or yield are often not made leading one to speculate as to what the disease impact might have been. At times disease assessment data are lumped into arbitrary groups to represent acceptable (commercial) control and non acceptable control. This is usually done with no support data and is to a degree both misleading and meaningless. While scientists usually agree that uniformity of assessment methods and estimates of disease impact are good ideas and even essential to proper communication, individuals cannot be compelled to use any "standard method". All manner of rationalizations are offered as to why standard methods should be used in an "ideal world" but simply cannot be used in a "real world". The chief rationalizations are issues of time and convenience. This applies to direct measures of disease impact as well. There is however considerable inconvenience involved where assessment methods are not uniform. When data is not uniformly expressed it becomes difficult to put together a clear package that represents the pecan industry as a whole. The EPA, for example, finds it very inconvenient to use data from six different states where the results are expressed in six different ways. It is very inconvenient to use data from one state to fill a gap in another state when an unfamiliar rating method has been used. There is also a quite correct feeling in industry, regulatory agencies and among plant pathologists that disease assessments alone without some measure of disease impact are quite useless.

This paper proposes to briefly discuss methods of assessing pecan disease incidence, severity and impact. Suggestions as to how methods could be standardized are included.

METHODS

Leaf Diseases. Several published and unpublished methods of assessing leaf diseases have been used. Leaf disease incidence has been expressed in terms of the percent of leaves or individual leaflets with disease present. This sort of evaluation can be done very quickly and easily. Disease incidence data is most useful when one diseased unit represents on unit of loss. (Brown rot in stone fruit is an example where a rotten peach is a rotten peach whether 1% or 100% rotted). This is not the case however for pecan leaf diseases. The two most common systems for evaluating pecan leaf disease severity have been reviewed (Bertrand and Gottwald 1981).

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The difficulty with these systems is two-fold. First; when rating whole compound leaves, disease severity is seldom enough to score a leaf above the three (Hunter and Roberts 1978) or four (Horsfall and Barratt 1945) lowest rating categories. Evaluating each individual leaflet may improve precision but takes considerably more time. Secondly there is no data to connect any level of disease severity with disease loss. Estimates of downy spot (Loustalot and Hamilton 1941) and scab (Gould et. al. 1996) severity on leaf physiology have been made. There is however no data on how these changes in leaf physiology effect yield or quality of pecans. In a downy spot study in 1996 (Bertrand unpublished) it was found that various levels of downy spot severity on terminals had no effect on nut size, quality or retention. In this study there was not the usual defoliation associated with downy spot. It is possible that the only damage from most leaf diseases is derived through defoliation. It has been demonstrated that late season defoliation by artificial means will reduce crop quality and quantity the following season (Worley 1979a, 1979b). Such data is lacking for defoliation caused by any disease. Pecan scab and possibly powdery mildew present a more complicated situation than other leaf diseases. With these diseases it is assumed that in addition to what ever unknown levels of leaf damage may occur, lesions serve as a source of inoculum for nut infections. There is no data however that links any particular level of leaf disease severity with any level of subsequent nut disease severity with either pathogen.

Severity of leaf disease can also be assessed by lesion counts. This can be very time consuming. It also becomes difficult when lesion counts begin to exceed 100 per compound leaf. At this point time consumption is extreme and precision is lost as it becomes impossible to separate large lesions from a coalescence of smaller lesions. Sporulating scab lesions may vary from 1 to 6mm in diameter thus simple lesion counts do not accurately reflect sporulation potential.

There is often not a good correlation between increasing disease incidence and increasing disease severity. In looking at pecan scab over the years the authors have observed that on sprayed or unsprayed trees most of the scab on terminals occurs generally on the same leaflet pairs on the same leaves. Thus differences in disease incidence may not separate treatments the same way as differences in disease severity (Table 1).

There is no clear best way to rate leaf diseases. An expanded scale such as the Horsfall-Barratt system should provide greater precision than the more compact scale of the Hunter-Roberts system. Precision can be increased along with assessment time by evaluating each individual leaflet. Some effort must be made to connect leaf disease severity with defoliation or some other measure of disease impact.

Nut Disease. Nut disease has been assessed by measuring incidence and/or severity. Disease incidence may be used to separate treatments when overall disease pressure to low as in dry seasons. However, disease incidence has no relation to disease damage except in the crudest possible terms. Nut disease severity is evaluated by the rating scales previously discussed (Horsfall-Barratt and Hunter-Roberts) or local variations of these scales. Actual % of shuck surface covered by disease is also used as a measure of nut disease severity. Any of the methods provide good correlations with nut quality as measured by nut size (Table 2). The relationship between severity estimates and quality as measured by % kernel is much less clear (Table 3). In the case of pecan scab, nut drop is also related to disease severity when severity becomes fairly high (Table 4). Disease severity is only partly related to yield and quality of pecans. It has been demonstrated that the greatest impact on the crop occurred with early infection (Gottwald and Bertrand 1983). One would expect that greater scab severity at shell hardening would be associated with earlier infections. This is a generally but unfortunately not absolutely true statement.

While there is no obvious "best" way to evaluate leaf disease, pecan nut disease may present a different situation. Expressing pecan nut disease severity as actual % of the shuck covered has several advantages. First, ease and convenience. Working with pecan scab the author has found in using rating scales a tendency to estimate the % coverage and then score the nut into the proper rating scale category. Simply recording % coverage avoids the mental conversion. Others may visualize a grading scale directly and this advantage real or not is actually minor. Second, actual % coverage is much more useful in presenting accurate disease progress analysis than data based on rating categories that do not reflect equivalent groupings, e.g, 0%, trace-6%, 6-25%, 25-50%, etc. Third, perhaps most important, our clientele (farmers, industry and regulatory personnel) can much more easily visualize the difference between 12% vs. 50%, shuck coverage than the difference between a category 3 vs. 5 in some rating scale. Rating scale values just do not mean much outside those using the particular scale.

Disease Impact. Assessment of disease incidence or severity has limited value unless connected to some estimate of disease impact. There is no data connecting any specific leaf disease to disease impact. The work of Worley (Worley 1979 a,b) suggests an impact of defoliation but defoliation data is almost never given as a part of leaf disease assessments. The situation with nut disease, particularly scab is different. Severity of nut scab is correlated with nut size as expressed by nut length or number of nuts per pound (Table 2). Nut length data is very time consuming to gather and has limited meaning to producers. Number of nuts per pound is easier data to generate and has great meaning to producers. However pound count data only implies size and the accuracy of the implication is only as good as the uniformity of the % kernel values. Where % kernel is variable it is difficult to take into account how this difference effects the pound count and how pound count reflects size. Differences in nut scab severity are not always correlated with differences in % kernel. Based on individual nuts there appears to be a consistent though fairly small effect of scab on % kernel (Stevenson and Bertrand unpublished). When 50-100 nut bulk samples are used these effects are not always seen (Table 3). Crop load, moisture availability, and other factors appear to affect % kernel more than scab and it is all but impossible to totally account for these factors.

Pecan disease may also effect yields. Yield can be measured by entirely harvesting plots which is very time consuming and not generally practical. Yield can also be estimated fairly accurately (Worley and Smith 1984). Accuracy of yield estimates are very much subject to tree uniformity. Trees under twenty years old are usually fairly uniform and it is fairly easy to eliminate obviously "different" trees. Mature trees (>50 yrs. old) tend to be very non uniform and many more trees are required to estimate yield with accuracy. Yield estimates are also influenced by the on year/ off year variation in individual trees which increases with tree age. Where actual yield data can not be gathered relative differences in disease loss in test plots can be obtained from determining differences in nut drop and weight/size values for remaining nuts. Nut drop % can be determined from numbers of nuts and nut scars on peduncles at various times during the season. Such data can allow calculation of relative disease losses between treatments where the best treatment is considered to have no loss.

DISCUSSION

Pecan disease assessments are done in a variety of ways. A grading scale may be the best way to evaluate leaf disease but there is no data relating leaf disease incidence or severity to disease loss. The same grading scales used for leaf disease assessments are used to make nut disease assessments. Actual % shuck coverage may be a better way to evaluate nut disease. Data gathered in this manner are more useful in showing disease increase over time and easier for a non plant pathologist audience to visualize. Measurements of disease impact are critical to any project where differences in disease are to be presented in any meaningful way. As input costs increase faster than commodity prices, farmers are becoming more aware than ever of the need to get tangible value for every input dollar. Pesticide development costs are rising every day. Industry needs good data on the relationships between reduced disease severity and reduced disease loss to help drive decisions on target markets for new products or continued use of old products. State and Federal regulatory agencies need clear pesticide impact data to justify new use and continued use of chemical pest management options.

Uniformity of assessment methods makes all data more useful beyond individual local needs and is very important.

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Table 1. Rating pecan leaf scab by severity and incidence on Desirable pecan in 1997[1]

Treatment (amount per acre)	% Leaflets with Scab	No. Scab Lesions Per Leaflet
Dodine (1 lb) + Enable (4 ozs)	9.6 A	<0.1 A
Super-Tin 80 WP (7.5 ozs)	75.3 B	4.8 B
Check	81.4 B	16.5 C

[1]In each column means followed by a different letter are significantly different ($p=0.05$).

Table 2. The effect of nut scab severity on final nut size in Desirable pecan[1]

Treatment (Amount/Acre)	% Shuck Covered with Scab 10 June	1 July	26 July	19 Aug[2]	Nut Length (mm)	# Nuts/Lb	% Kernel
DOUGHERTY COUNTY							
Super-Tin (1/2 rate) + Enable (4 ozs)	0.27 A	0.4 A	3.5 A	10.7 A	39.9 A	55.5 A	54.7 A
Dodine (1 lb) + Enable (4 ozs)	0.22 A	0.4 A	4.8 AB	13.1 A	38.8 A	56.5 A	54.6 A
Super-Tin/Orbit Co-pack (as label)	0.23 A	0.6 A	6.5 B	14.5 A	38.3 A	55.8 A	54.5 A
Super-Tin 80WP (7.5 ozs)	0.01 B	1.4 A	10.6 C	24.1 B	36.4 B	62.8 A	54.2 A
Check	0.54 C	16.9 B	86.6 D	90.1 C	30.7 C	110.5 B	50.2 B
MITCHELL COUNTY II							
Super-Tin (1/2 rate) + Enable (4 ozs)	0.04 A	0.23 A	4.3 A	10.2 A	39.2 A	67.3 A	49.4 A
Dodine (1 lb) + Enable (4 ozs)	0.02 A	0.22 A	3.8 A	8.7 A	38.2 A	69.9 A	49.5 A
Super-Tin/Orbit Co-pack (as label)	0.02 A	0.35 A	9.0 B	19.2 B	38.2 A	67.5 A	49.1 A
Super-Tin 80WP (7.5 ozs)	0.02 A	2.12 B	26.5 C	40.6 C	35.2 B	85.4 B	47.7 A
Check	0.18 B	15.63 C	84.1 D	71.2 D	32.5 C	91.1 C	49.4 A

[1]For each location numbers in the same column followed by a different letter are significantly different (p=0.05).
[2]Shell hardening

Table 3. The inconsistent effect of nut scab on % kernel in 50 nut bulk samples of Desirable pecan

Location[1]	Treatment	Nut Scab[2]	% Kernel
Mitchell County 1994	Check	61.9 A	46.6 A
	Treated	8.4 B	48.7 A
Berrien County 1994	Check	64.0 A	45.7 A
	Treated	11.7 B	45.1 A
Lee County 1994	Check	56.9 A	44.8 A
	Treated	10.1 B	52.3 B
Berrien County 1995	Check	25.2 A	51.6 A
	Treated	2.8 B	54.5 B
Mitchell County 1995	Check	66.9 A	52.4 A
	Treated	18.0 B	53.4 A
Dougherty County 1997	Check	90.1 A	50.2 A
	Treated	10.7 B	54.7 B
Mitchell County 1997	Check	71.2 A	49.4 A
	Treated	8.7 B	49.5 A

[1]For each location, numbers in the same column followed by a different letter are significantly different (p=0.05).
[2]Average % of the shuck surface covered by scab at shell hardening.

Table 4. The effect of high scab severity ratings on early nut drop of Desirable pecan[1]

Treatment	% Shuck Covered with Scab 10 June	1 July	26 July	19 Aug[2]	% Nut Drop (Aug-Sept)
DOUGHERTY COUNTY					
Dodine (1 lb) + Enable (4 ozs)	0.22 A	0.4 A	4.8 A	13.1 A	12.1 A
Super-Tin 80WP (7.5 ozs)	0.01 B	1.4 A	10.6 B	24.1 B	10.8 A
Check	0.54 C	16.9 B	86.6 C	90.1 C	93.7 B
MITCHELL COUNTY					
Dodine (1 lb) + Enable (4 ozs)	0.02 A	0.22 A	3.8 A	8.7 A	24.1 A
Super-Tin 80WP (7.5 ozs)	0.02 A	2.12 B	26.5 B	40.6 B	33.1 A
Check	0.18 B	15.63 C	84.1 C	71.2 C	87.2 B

[1]For each location, numbers in the same column followed by a different letter are significantly different (p=0.05).
[2]Shell hardening