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# INSTRUMENTAL MEASUREMENT OF LEAF GRADE: PROGRESS REPORT

**Preston E. Sasser**
**Schaffner Technologies, Inc**
**Knoxville, TN**
**Sunho Lee**
**Schaffner Technologies, Inc**
**Knoxville, TN**
**Yupeng Zhang**
**Schaffner Technologies, Inc**
**Knoxville, TN**
**C. Kyle Shofner**
**Schaffner Technologies, Inc**
**Knoxville, TN**
**Frederick M. Shofner**
**Schaffner Technologies, Inc**
**Knoxville, TN**

## Introduction

The purpose of this presentation is to report to you the progress that is being made in developing instrument methods that are accurate, precise, repeatable and reliable enough to replace the human classer in the commercial determination of trash (leaf grade) in ginned cotton. This report includes the analysis of data from 2429 samples that were tested for color and trash content by the USDA, AMS in Memphis, TN. Only an analysis of the trash data is included in this report.

## Samples

The samples used in the tests reported herein were obtained by the AMS, USDA at the Memphis office from the 2004-05 U.S. upland crop. The samples are best described as classer's samples taken from bales, usually at the cotton gin, and sent to a local USDA office for classing. The samples were then sent to the Memphis office where they were classed by three additional different USDA classers, and tested on an HVI system and two IsoTesters®. The HVI instrument was manufactured by the Uster Company and was in the standard configuration used by the USDA in their Classing Offices and laboratories. The IsoTesters were manufactured by Schaffner Technologies, Inc. All instruments were owned and operated by the AMS, USDA. All testing and classing were done by USDA personnel. The IsoTesters measured only color and trash and were calibrated to HVI levels for those properties. The IsoTester has been described in some detail in previous Beltwide Conference papers by Dr. Fred Shofner and others (1) and those details will not be repeated here. The intent was to have a set of samples with a wide range of fiber properties from all the different producing regions in the U.S. The sample set contained samples with classer leaf grades from 1 to 8 (BG).

## Data Analysis

A total of 5080 samples were tested as described above. The bale identification numbers were stripped from the data set and the data supplied to us by the USDA. The human classer leaf grade (HC LG) data were first analyzed to determine the agreement among the classers in their determination of that property. To evaluate the ability of the IsoTesters to predict the classers leaf grade, we selected a subset of 2429 samples (from the original 5080 samples) for which three of the four classers agreed on the leaf grade. We selected this subset of samples in which three classers all agreed on the leaf grade in an attempt to eliminate as much experimental error as possible in the independent variable (human classer leaf grade) for our analysis. The remainder of this presentation will be a report on how well the IsoTesters performed in predicting the leaf grade of samples that three cotton classers (working independently) had all agreed on the leaf grade of each sample. The general performance characteristics of these IsoTesters were reported in papers given at the 2005 Beltwide Conference (1).

### Agreement between IsoTesters

First, let's look at how the IsoTesters performed relative to each other. The instruments were labeled ISO1 and ISO2. The trash data are reported by these instruments as percent area (%A) and count (Ct). The data are obtained by scanning the surface of the cotton sample. Figure 1 gives a x-y plot of the trash count data on the 2429 samples from the two instruments. The range of count data is from about 5 to almost 140. A linear regression for the data has a slope of 0.969 and an offset of 1.45. The R-square value is 0.971. Figure 2 gives the trash percent area data for the samples. In this case the linear regression has a slope of 0.963 and an offset of only 0.024. The R-square value is 0.952. The data in these two graphs show that the two instruments were calibrated to much the same level and produced data that are in close agreement.

The trash percent area and count data were used to calculate a predicted leaf grade for each bale sample using the circular chart method described by Shofner in his 2005 Beltwide Conference paper (1). See Figure 3 for a printout of the conversion chart used in this paper. The calculated (predicted) leaf grade values were truncated to whole numbers and the single digit numbers (1 through 8) are used in this report. The agreement in predicted leaf grade between the two IsoTesters is shown in Figure 4. The regression slope of 0.934 and an R-square value of 0.92 indicate good agreement. However, it is interesting to look at the range of leaf grade values found by one of the instruments when looking at samples within a single leaf grade as determined by the other instrument. For example, among the samples that a leaf grade of 1 was found by ISO1, ISO2 found leaf grades of 1,2 and 3. On the other hand, ISO1 found leaf grades of 1 and 2 among the samples determined with leaf grade 1 by ISO2. We will examine this idea in further detail when we discuss the human classer versus ISO leaf grades.

See Figure 5 for a graph that shows the agreement in predicted leaf grade between the two IsoTesters. For the entire set of 2429 samples, the two testers agreed exactly on the same leaf grade for 82.1 percent of the samples. The ISO1 tester predicted one leaf grade

higher (more trash) on 7.5% of the samples and one leaf grade lower (less trash) on 10.3% of the samples than did the ISO2 tester.

We conclude by this simple analysis that the IsoTesters were calibrated to the same level for trash area and count, and that these instruments give the same predicted leaf grade values within experimental error.

**Human Classer versus IsoTester Leaf Grades**

Since the IsoTesters gave comparable results, ISO1 instrument data will be used to examine the ability of the testers to predict the classer leaf grade. Table 1 gives the distribution of the leaf grades by both instrument and classer for the entire subset of 2429 samples. These data (percent distribution) are shown graphically in Figure 6. The original intent of the sample collection process was that the distribution across the leaf grades would be flat (i.e. same number of bales in all leaf grades). However, it proved difficult to get some samples with high leaf grades from some areas and the decision to select a subset of samples in which at least 3 classers agreed on the leaf grade skewed the distribution. Thus, no significance should be given to the shape of the overall distribution.

TABLE 1. Distribution by leaf grade for 2429 samples.

| | NUMBER OF SAMPLES | | PERCENT OF SAMPLES | |
|---|---|---|---|---|
| LEAF GRADE | HC LG | ISO1 LG | HC LG | ISO1 LG |
| 1 | 516 | 439 | 21.2 | 18.1 |
| 2 | 256 | 406 | 10.5 | 16.7 |
| 3 | 649 | 607 | 26.7 | 25.0 |
| 4 | 541 | 468 | 22.3 | 19.3 |
| 5 | 208 | 338 | 8.6 | 13.9 |
| 6 | 205 | 162 | 8.4 | 6.7 |
| 7 | 49 | 8 | 2.0 | 0.3 |
| 8 | 5 | 1 | 0.2 | 0.04 |

The data in Table 1 and Figure 6 show that the ISO1 instrument put 6.2% (16.7-10.5) more of the samples into leaf grade 2 than did the classers. These samples come mostly from HC LG 1 (3.1%) and HC LG 3 (1.7%). Overall, the classers put more samples in LG 1, 3, 4, 6 and 7 while the instrument put more samples into LG 2 and 5. Nevertheless, the overall average leaf grades were 3.21 for HC LG and 3.16 for the ISO1 LG. Figure 7 shows the level of agreement between the classers leaf grade and the ISO1 predicted leaf grade. The instrument predicted the exact same leaf grade as the classers for 70.7% of the samples. The instrument's prediction of leaf grade was different from the classers leaf grade by one leaf grade for 28.4% of the samples (15.9% were one LG higher and 12.5% were one leaf grade lower.

If human classer leaf grade is used as the independent variable and plotted against the leaf grade as predicted from the IsoTester count and percent area readings, the results presented in Figure 8 are obtained. We see in comparing the data in this graph with those

in Figure 4, which gives instrument-to-instrument results, that the slope of the line is lower (0.876 vs. 0.934) and the R-square is lower (0.879 vs. 0.920). The slope of the regression line can be improved (to approach an ideal 1.0) by adjusting the algorithm by which we calculate the predicted leaf grade. The lower R-square suggests that there is more scatter around the regression line in Figure 8. We note from Figure 8 that the instrument predicted leaf grades 1 and 2 for the samples that the classers had called leaf grade 1, the instrument predicted leaf grades 1, 2 and 3 for the samples that the classers had called leaf grade 2, etc. Table 2 below gives the percentage breakdown of the samples put into each leaf grade by the instrument within each classer leaf grade. In the table we see that for the samples that the classers agreed have a leaf grade of one, the ISO1 instrument put 73.4 percent of them in leaf grade 1 and 26.6 percent of them in leaf grade 2. The data in this table are shown in graph form in Figure 9. Note from the data in the table and graph that the instrument put approximately 70 to 80% of the samples in exactly the same leaf grade as the classers for leaf grades 1, 2, 3, 4 and 5. Some additional work needs to be done on the algorithm to calculate leaf grade for leaf grades 6 and 7. No conclusions will be made regarding leaf grade 8 (BG) because only 5 samples were in this group.

TABLE 2. Distribution of ISO1 Leaf Grades within the Human Classer Leaf Grades (Percent)

| ISO1 LG | HC LG 1 | HC LG 2 | HC LG 3 | HC LG 4 | HC LG 5 | HC LG 6 | HC LG 7 | HC LG 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 73.4 | 21.9 | 0.6 | | | | | |
| 2 | 26.6 | 69.1 | 14.2 | | | | | |
| 3 | | 9.0 | 79.5 | 12.6 | | | | |
| 4 | | | 5.7 | 71.7 | 17.3 | 3.4 | | |
| 5 | | | | 15.5 | 73.1 | 46.3 | 14.3 | |
| 6 | | | | 0.2 | 9.6 | 49.3 | 77.6 | 40.0 |
| 7 | | | | | | 1.0 | 8.2 | 40.0 |
| 8 | | | | | | | | 20.0 |

**Human Classer verses HVI Leaf Grades**

To get a reference relative to how well the current HVI technology predicts the human classer leaf grade; the samples were tested on a HVI system in the Standards Department, AMS, USDA in Memphis. Those data are presented in Figures 10 and 11. Figure 10 (similar to Figure 6) shows how the leaf grades are distributed for the set of 2429 samples for both human classer results and predicted leaf grade using the HVI measured percent trash area and trash count data. Figure 11 (similar to Figure 7) shows that the HVI data predicted the human leaf grade exactly for 61.2% of the samples, and predicted one leaf grade different that the classers for 37.5% of the samples, and two or more leaf grades different from the classers for 1.2% of the samples.

## Conclusions

The data presented here suggest that significant progress is being made in developing the technology needed to determine the classer leaf grade by instruments. These data show that the current HVI technology predicts the classer leaf grade exactly about 61% of the time while the IsoTester technology predicts the classer leaf grade exactly about 71% of the time. When the instrument-to-instrument agreement is considered, the IsoTesters instruments agree on the exact same leaf grade 82% of the time. Thus, we conclude that significant progress is being made in developing rapid and reliable instruments that predict human classer leaf grade with a sustainment on retest that is as great or greater than the classer retest sustainment.

## Reference

1. Shofner, Fred, et al. Proceedings of Beltwide Cotton Conferences. January 2005.

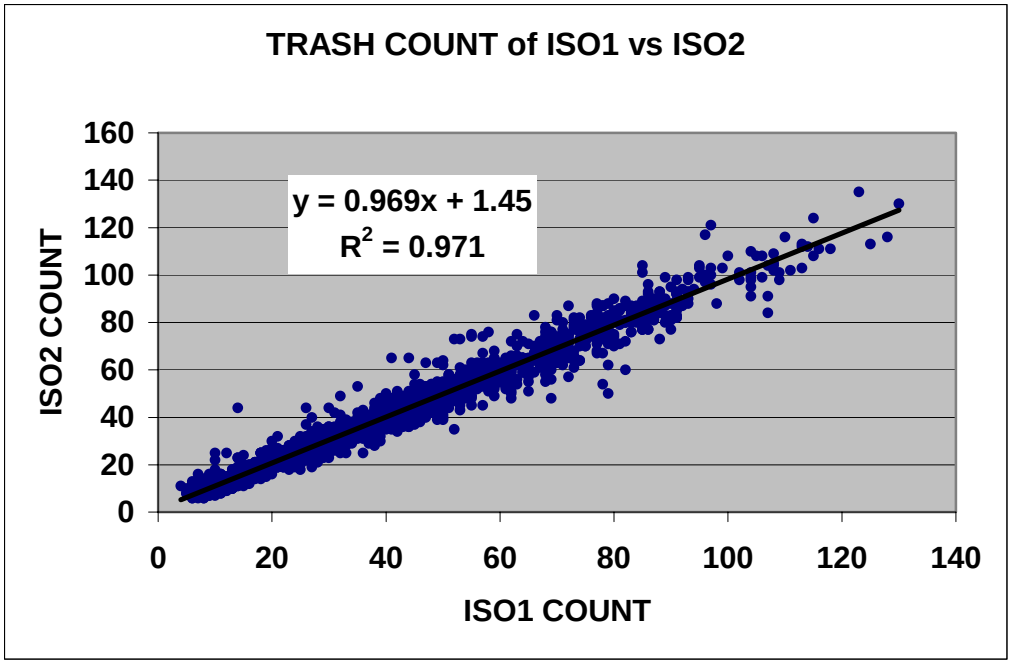


Figure 1.

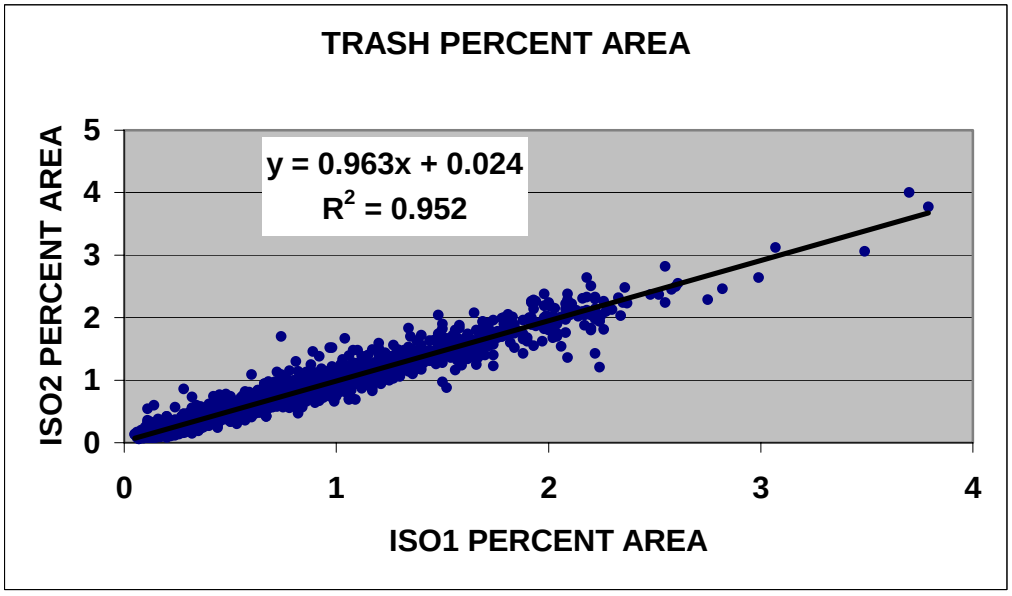


Figure 2.

[ Circular Chart for LG = f(Ct, %A) ]
Figure 3.

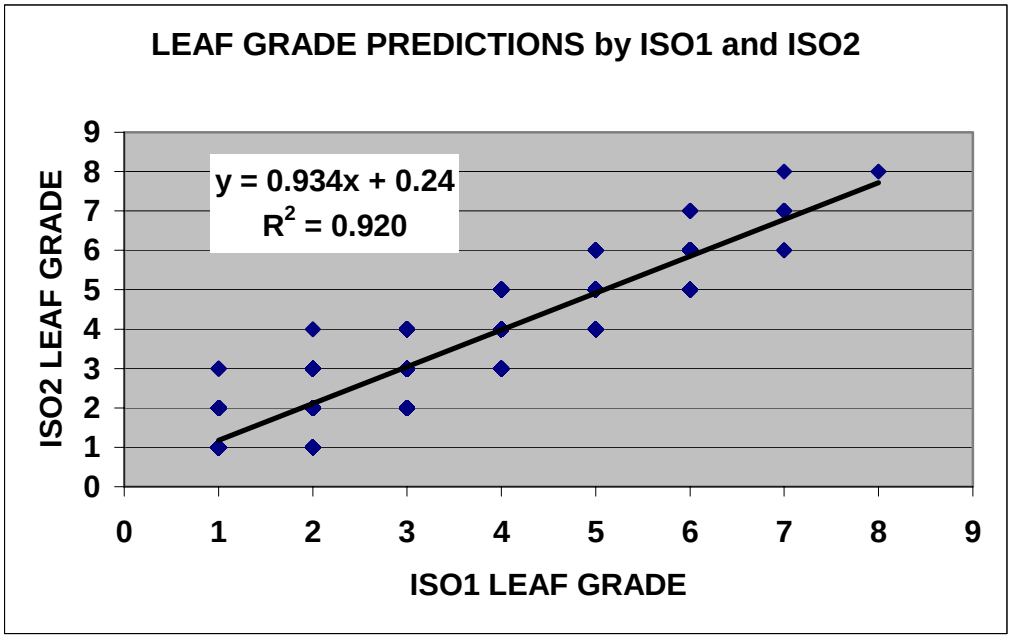


Figure 4.

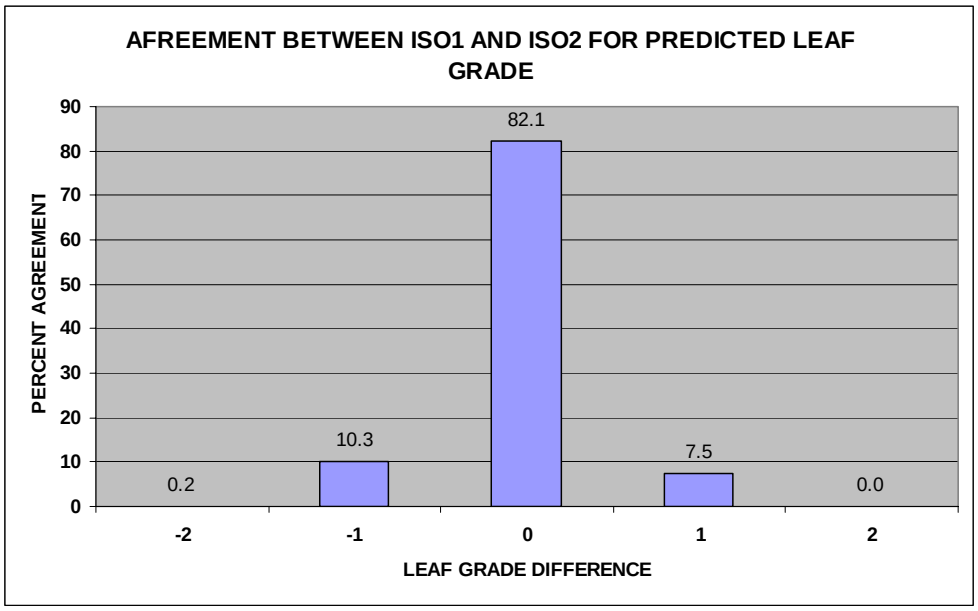


Figure5

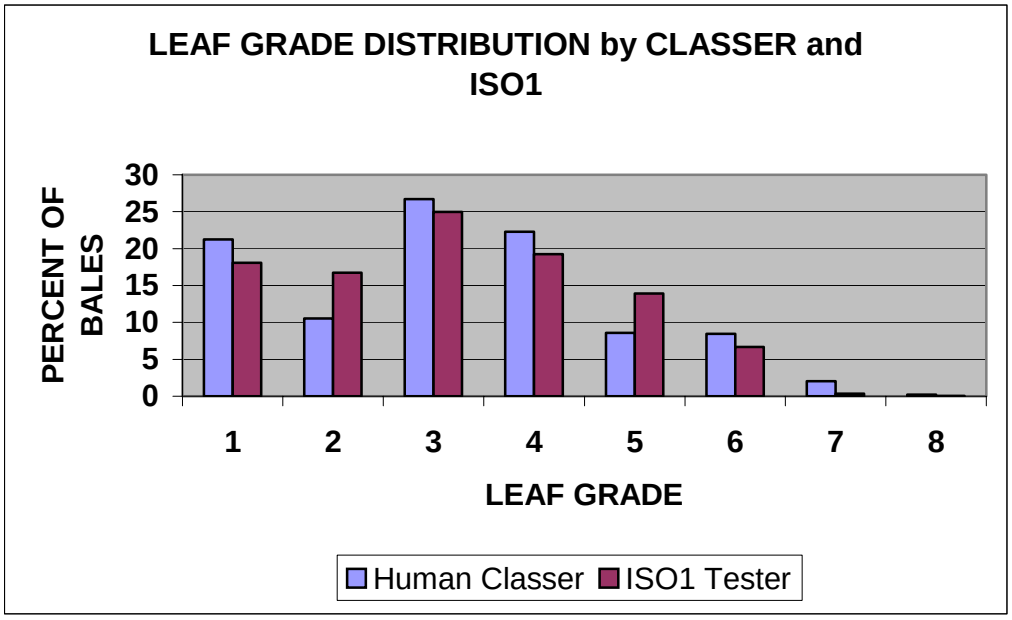


Figure 6.

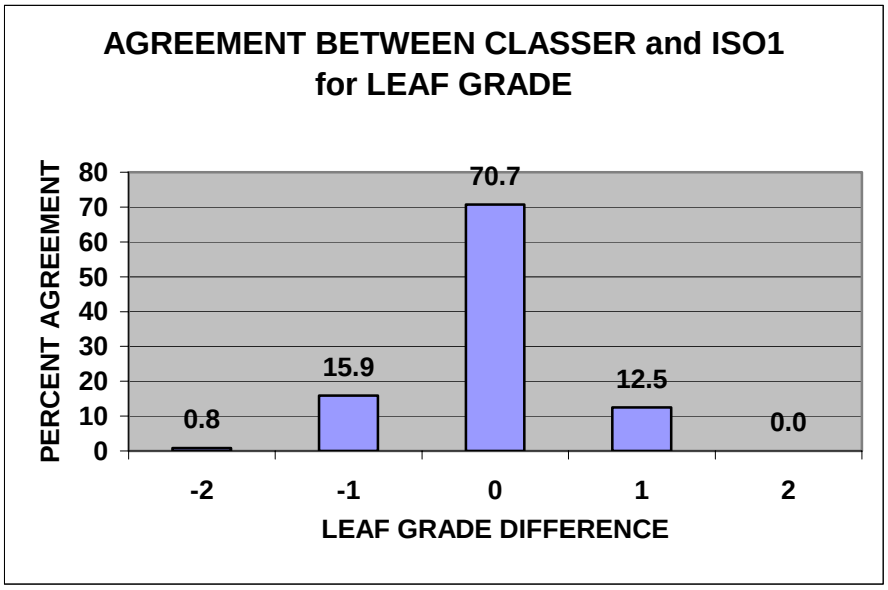


Figure 7.

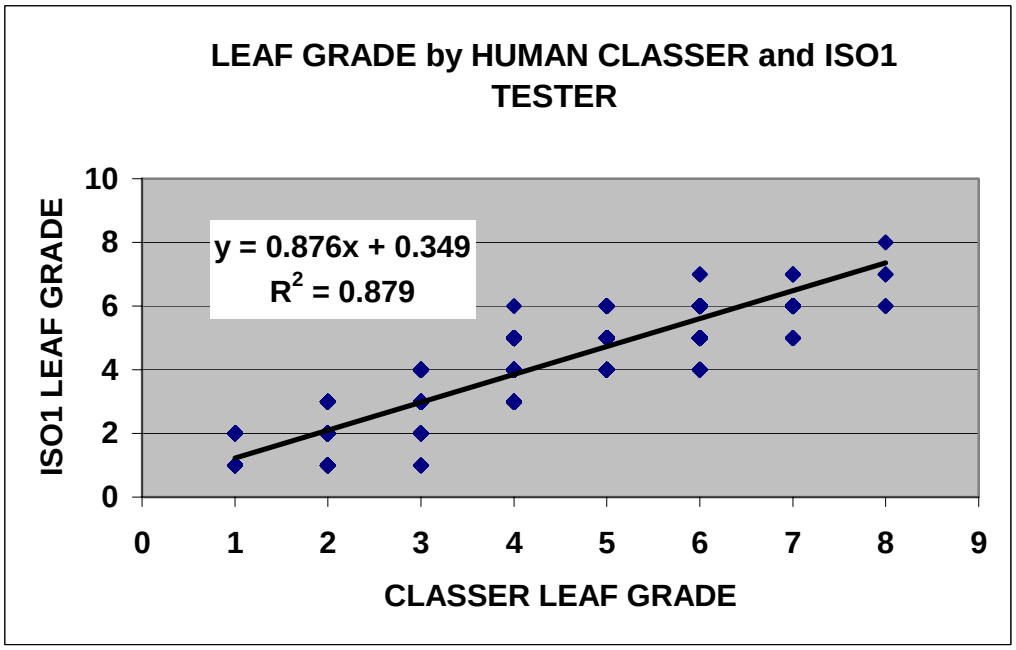


Figure 8

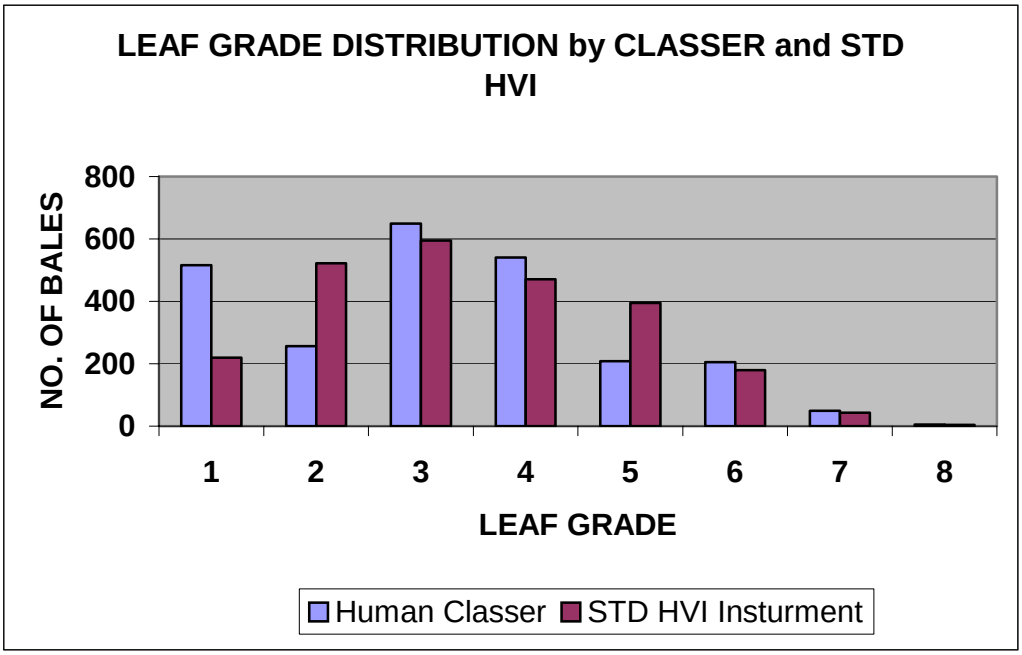


Figure 9

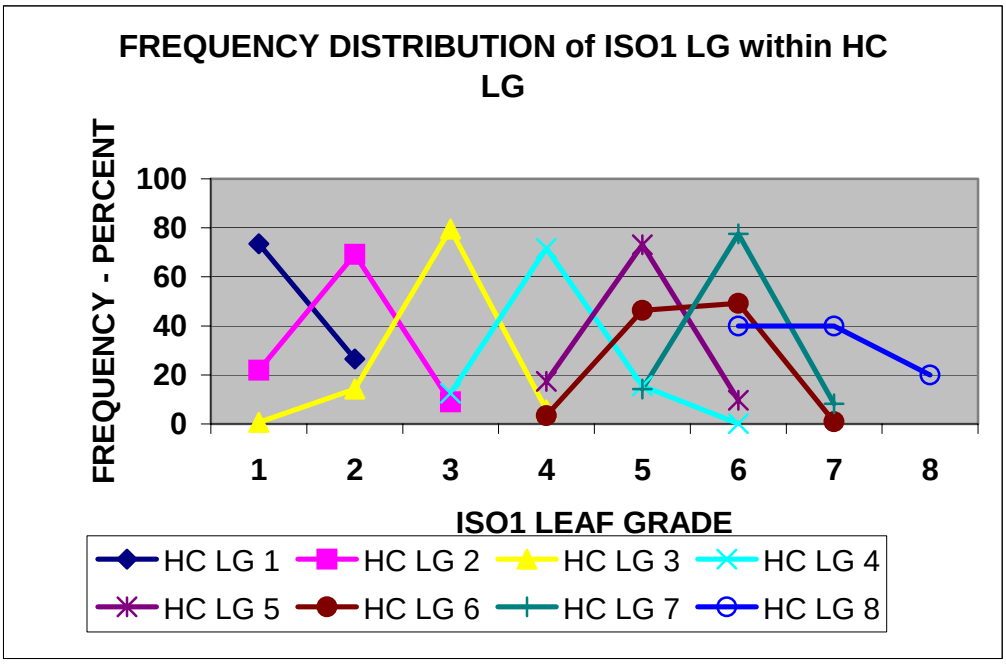


Figure 10

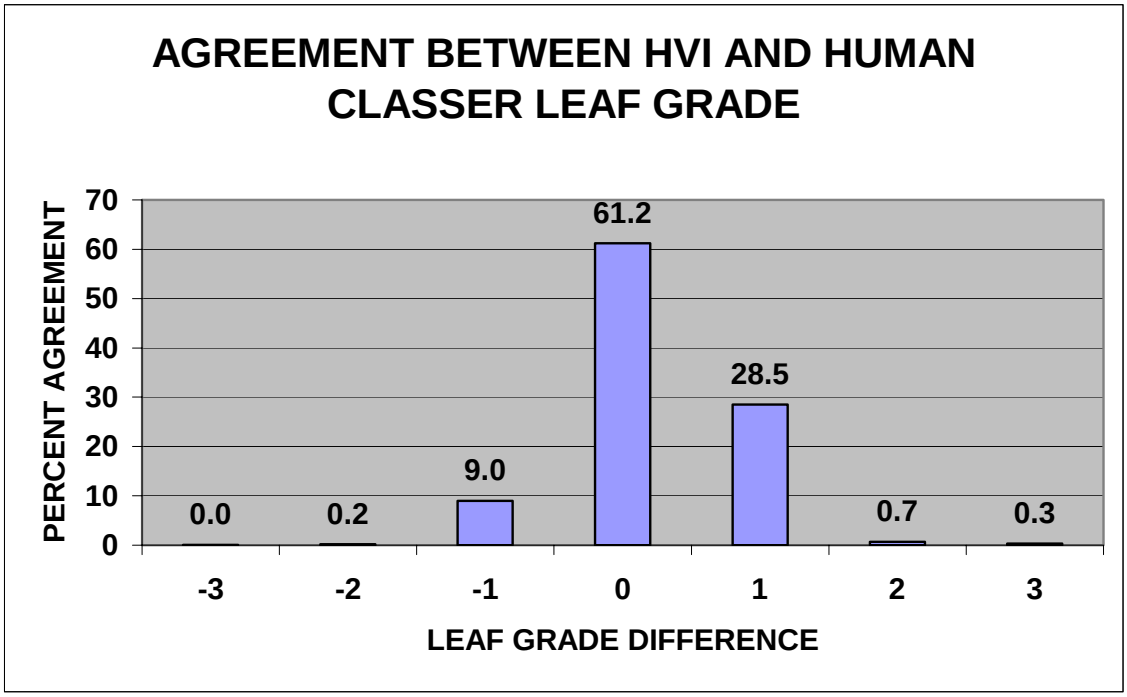
AGREEMENT BETWEEN HVI AND HUMAN CLASSER LEAF GRADE
PERCENT AGREEMENT
70
60
50
40
30
20
10
0
0.0
0.2
9.0
61.2
28.5
0.7
0.3
-3
-2
-1
0
1
2
3
LEAF GRADE DIFFERENCE

Figure 11