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DEVELOPMENTS OF INSTRUMENT BASED LEAF GRADE

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Abstract

Since 2000, the USDA Cotton Program has been assessing the viability of moving towards an instrument determined leaf grade. Currently the High Volume Instrument (HVI) line measures non-lint trash in two ways: percent area and particle count. Data was gathered from all Quality Assurance check-lot bales for four crop years (2000, 2001, 2002 and 2003) and used to develop and refine a lookup table from which a leaf grade can be derived from the percent area and particle count measurements. Improvements are currently being made to the measurements of percent area and count data that is being obtained from the instrument. The Cotton Program is extending its efforts into other instrumentation in addition to the current HVI. New instrumentation offers possible improvements in utilizing different technologies and larger surface area measurements. The Cotton Program will be evaluating the improvements to determine the best utilization of instrumentation to deliver an instrument trash measurement that corresponds with the current classer leaf grade.

Introduction

The Cotton Program is continuing in its efforts to pursue further migration towards a fully instrument based classing system. Great strides have been made over the past several years with the latest evolution being made in the color measurement. Similar strides are being made in the area of the instrument based trash measurement. The cotton industry is greatly impacted by the amount of trash content within cotton bales. This foreign matter within the cotton lint is inherent to the cotton processing due to the mechanized harvesting practices throughout the country. There is a variety of harvesting equipment available on the market and each one has an impact on the amount of foreign matter that contaminates the lint. Equipment such as cotton pickers are designed to pick the lint with a minimum amount of foreign material. Cotton strippers, on the other hand, are designed to be much more aggressive and strip the plant gathering a large amount of foreign material.

The USDA cotton classing system utilizes approximately 350 manual classers across 12 program offices. All classers are currently trained in a 7 week training program where they are taught how to differentiate between the various levels of leaf grade in addition to determining if extraneous matter exists in a sample. The classers utilize Universal color and leaf grade cotton standards in the determination of leaf grade. The Universal standards are created on an annual basis and expire every year on June 30th. Each year, a group, representing the cotton industry convenes at the USDA office in Memphis, Tennessee in an effort to review and approve the Universal color and leaf grade cotton standards for the coming season. These leaf grade standards are created by carefully placing and/or removing leaf and trash particles in order to most accurately represent the original 1986 Universal color and leaf grade cotton standards that continue to serve as the basis for cotton standards. The grade standards are not an exact representation of all of the cotton samples that are graded. The cotton samples that are received during the season vary not only in the amount of leaf and trash content but in particle size as well. Therefore, there is a certain amount of subjectivity in the current classing system that is very difficult to standardize. The Cotton Program addresses this by close supervision of the classers through office visitations by the Quality Assurance Branch and the Grading Branch in addition to the immediate supervision received within the office by classer supervisors on a constant basis.

The human eye is influenced by such things as color degradation and sample preparation. This effect is referred to as visual acuity which “is the ability to detect small details and to discriminate small objects.” (Kroemer and Grandjean) It is much easier for the human eye to detect the trash content and amounts in a bright white background such as a good middling white or strict middling white cotton than with a dull or colored background such as a low middling light spotted cotton. The USDA, AMS, Cotton Program has strict requirements on the lab lighting and the painted surfaces in an effort to reduce these effects.

Instrumentation

The current instrumentation operated in USDA, AMS, Cotton Program classing offices is the Uster model 900-U that utilizes a black and white camera with a viewing area of nine square inches. Two halves of the cotton sample is placed in two trays and the samples are transported into an area where two images are analyzed at the same time. An image is taken from the bottom and top portions of both halves of the sample for an average of four image readings. The total measurement area of thirty six square inches is analyzed in the calculation of the average trash content. The instrument utilizes two measurements in the analysis of trash content. The percent area analyzes all pixels that are covered with trash particles and then divides that pixel count by the entire pixel count for that area. This results in a measurement that is a percent of the overall measured area. The count is considered to be a common cluster of pixels that are connected. A summation of the clusters in the measurement area is then averaged the same as the percent area.

The setup practice of the trashmeter is a very detailed process that involves several different tiles and verification materials. The technician or supervisor utilizes 13 setup tiles in the process. These tiles are used to verify clean measurement equipment and surfaces, correct and constant window sizes, proper camera focus and threshold constants, and the proper corrections for particle size deflation. Particle size deflation is something that has to be corrected in the instrument calibration and a detailed procedure was adopted in 1998 (Knowlton, 1997). Early in the development of the instrument trashmeter, a single calibration tile was used to establish and maintain the testing level. Further evaluations revealed that a single calibration tile was not adequate to stabilizing the trashmeter level (Randle, 1992). A new set of standards were created utilizing cottons. A set of cottons with varying amounts of trash content were placed in containers under glass in an effort to create a testing level comparable to that of actual cottons (Knowlton, 1999).

Implementation of Instrument Changes

The Cotton Program has implemented several changes in the instrument trash measurement in the 2004 crop year. Some of these have been in place for years but were revised this past year. Other changes were implemented for the first time this year and are in an analysis phase of development.

In the fall of 1997, an edit was placed within the computer system that would check the classer leaf grade call against the percent area measurement. This edit is predominantly used on the white and light spotted color grades with a few exceptions. Extraneous matter is one of the exceptions to this edit since it is identified by the instrument as trash. The edit was implemented to facilitate a review of the samples by the classer and/or the instrument on samples that had a large disparity in the trash measurement as it corresponds to classer leaf grade. This edit has undergone numerous changes since it was first implemented and this current year the tolerances were narrowed on the edits to further scrutinize the trash measurement. This change revealed some problems with the comparison of the measurements. There are certain samples with a duller, yellowing background and a rougher preparation where the human eye and the instrument tend to disagree. In these cases, the instrument tends to identify more trash in the sample as compared to the observation of the classer. These samples are a cause for concern due to the distinct disagreement. Investigations have been made and will continue in an effort to discern whether the instrument is detecting redness or shadowing in the lint as non-lint or trash material.

The instrument measurements of percent area and count have been improved through enhanced data collection. The 2004 crop year will be the first year that the Cotton Program has collected and evaluated the particle count data and the percent area to the nearest hundredth in the checklot and classing office data. This data has been used in the further development of reports in an effort to evaluate office performance on this measurement which will be described later. This additional test data should be useful in the development of tighter controls that should perpetuate into improved performance of the measurement throughout the range of trash levels in the crop.

The USDA, AMS, Cotton Program monitors its performance on all measurements through its checklot program. Approximately 1 percent of the samples in each classing office are selected at random by the computer system for further evaluation. These samples are sent to the Quality Assurance Branch each day where they are retested. Specified tolerances are applied to each of the measurements based upon expected measurement variability in an effort to monitor instrument performance. A new theoretical tolerance method has been under evaluation this year with the additional data that has been available in the trash measurement. The trash measurement is a unique measurement due to the increased variability in the measurement as the trash level in the sample increases Therefore, an experimental approach using incremental tolerances to properly analyze the performance of the measurement throughout the range was developed. The other instrument measurements have a single tolerance due to the fact that their variability is fairly constant throughout the range. The trash measurement has an incremental tolerance that widens as the trash increases. The percent area has had a two step tolerance for several years. This was due to the lack of a decimal place in the data. Samples with trash contents lower than 0.5 based off of Quality Assurance test results would be subject to a 0.1 tolerance and the heavier trash samples would be subject to a 0.2 tolerance. The additional decimal within the percent area measurement provides the ability to apply tighter tolerances that enables tighter monitoring and controls on the percent area measurement.

Software changes were implemented in the 2004 version of the instrument operation. A change was made in the system testing or operational mode of the instrument that verifies complete sample coverage over the window of the testing area. The software currently provides the flexibility of selecting the optimum constant for determining the maximum cluster size. This feature enables the USDA to optimize this constant in order to maximize the capability of this feature. In addition to this feature, other features were provided in an effort to more closely monitor instrument setups and performance. Sets of trash reference tiles are supplied to each office with standardized values. These tile sets are referred to on a weekly basis as a verification of proper instrument setup and maintenance. This information is transmitted electronically into the main computer system where this information can be monitored and reported to the Quality Assurance Branch in Memphis, Tennessee.

Due to the large range in both the count and percent area measurements, it is difficult to set a fixed upper limit on either one. However, by comparing the magnitudes of the two measurements it is possible to set a limit on allowable values and eliminate many “wild readings” attributable to either incomplete window coverage or problems in the HVI. This is being accomplished by setting a tolerance on the ratio of count to percent area. If a sample tests outside of the acceptable range of ratios, it will be flagged for retest.

These changes will assist in the movement towards instrument classification by ensuring that all instruments measure on the same level, by controlling against operator errors or machine problems, and by providing more accurate and useful information on trash levels in the sample.

Chart Development

The initial chart development began with the evaluation of the 2000 crop in the Quality Assurance Branch. This database was essentially based upon approximately 1 percent of the entire 2000 crop evaluated throughout the length of the season. The development was restricted to this data set simply because it was the only data that contained the count measurement. In the early stages of the development process, it was learned that the count measurement provided very beneficial information in the prediction of the classer leaf grade. This work led to the development of a rectangular chart that was focused on the agreement to the Quality Assurance classers and the checklot system.

Over the past several years, there have been several methods developed for using instrument trash data (specifically, particle count and percent area) to determine a leaf grade. Each method utilizes both of these measurements, as neither alone is sufficient to determine the grade.

The initial method involved constructing a table of all possible combinations of particle count and percent area. For each combination of the two, the predominant leaf grade was determined based on classer calls. For instance, a given combination of count and percent area may correspond to 12 classer calls of leaf grade 2, 39 classer calls of leaf grade 3, and 21 classer calls of leaf grade 4; in this case, that cell would be designated as leaf grade 3. The reasoning behind this method was that it was important to maximize reproducibility against the human classer. However, there are certain problems associated with this method. First, due to the large amount of overlap in classer leaf grades across the measurements, the maximum theoretical reproducibility is very limited- approximately in the low 70-percent range. Also, the crop is not uniformly distributed- and is actually highly skewed towards the middle grades. This means that, in order to maximize reproducibility, it is vitally important to have high performance in the most prevalent grades (leaf grades 3, 4, and 2, in that order), and much less important to perform well in the less common grades. Consequently, while a lookup table constructed with this method fares relatively well against the entire crop distribution as a whole, it performs poorly when tested across a wider range of cottons.

One possible method to remedy the problem of skewing in the crop is to attempt to level reproducibility across grades, rather than to simply try to maximize reproducibility against the human classer. To do this, a similar process is used as in the first method. However, rather than assigning a cell a leaf grade according to the predominant human classer call, a cell is assigned a grade based on which leaf grade has the highest percentage of its total in the cell. For instance, if a certain cell contains 12 classer calls of leaf grade 2 (which may be, for instance, .0015% of all leaf grade 2 calls), 39 classer calls of leaf grade 3 (.0002% of all leaf grade 3 calls) and 21 classer calls of leaf grade 4 (.0009% of all leaf grade 4 calls), then by this method the cell would be designated as leaf grade 2. This would help prevent the most numerous leaf grades from swamping the other calls through sheer numbers, which should level reproducibility across the leaf grades.

Another method currently under investigation involves decoupling the instrument leaf grade from the classer leaf grade. To do this, a centerline would be drawn through the crop distribution and perpendicular lines to it would be placed to divide the crop into leaf grades. The perpendicular lines would be placed in such a way as to keep the distribution of the crop the same- for instance, if the crop contained 5% leaf grade 1 cotton and 15% leaf grade 2, then the first line would be drawn to take in the cleanest 5% of the crop based on particle count and percent area for leaf grade 1, while the next line would be drawn to take in the 6^{th}-20^{th} percentiles for leaf grade 2. This approach is a significant departure from the other methods in that it completely removes the human classer from the process. However, it would keep the overall crop distribution the same (although the distribution would shift for individual regions) and establish clear boundaries across all offices for each leaf grade.

Discussion

The complete agreement between the human eye and the instrumentation presents a difficult uphill battle. There are certain things that an instrument is limited by and one of those limitations is subjectivity. It is difficult to program an instrument to make discernments in samples that do not conform to the norm in a particular measurement. The individual measurements of percent area and count are utilized in the final determination of leaf grade. The trash measurement is a calculation of the average of 4 tests on a total surface area of 36 inches. Possible improvements to this test could be in the expansion of the total surface area. This could potentially increase the reliability of the measurement.

Another problem of the implementation of the instrument leaf grade is the limitations that are being placed upon the instrument measurements. The current marketing system was developed around the human classification system and this system has not changed since the development of the instrument. The instrument measurements have always been forced to conform to the existing marketing system. This is a constraint on the instrumentation measurements. There is far more information in the individual measurements of Rd, +b, percent area, particle count than the traditional and larger groupings of staple, color grade and leaf grade. Although the instruments have the ability to pinpoint a more accurate description of the cotton, it is limited to the traditional boundaries based upon human measurements. A leaf grade 2 is not a finite range of percent area and count. It represents a fairly large scale and gives no additional information regarding the particles that are making up the trash content. The particles could be a large amount of very small particles or a small amount of large particles. An instrument leaf grade of 2 could not reveal this information; however, the separate measurements of percent area and count would provide an insight to the particle size makeup.

Conclusion

The Cotton Program will continue in its pursuit of instrument leaf grade. As was indicated earlier, the measurement could be improved by enlarging the measurement area. The Cotton Program is currently evaluating an Isotester instrument that is manufactured by Schaffner Technologies. This instrumentation is dramatically different from current USDA instruments since it does not currently test all of the fiber properties. This instrument utilizes scan technology and has demonstrated some potential improvement to the trash measurement. The instrument has a viewing window area of twenty eight square inches versus the current nine square inches. This results in a total difference in the measurement area of one hundred twelve square inches versus thirty six inches which is over three times larger. The Cotton Program will continue in the evaluation of new instrumentation and the existing instrumentation in an effort to further the utilization of instrument testing where feasible.

References

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