

EXPERIENCE MEASURING EXTRANEIOUS MATERIAL IN COTTON SAMPLE BY CONTEST[®] AND FIBERMAP[®]

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ABSTRACT

CONTEST[®] original technology was born for testing impurities and contamination of cotton including Trash, Leaf, Seed coat fragments (SCF), Neps and Stickiness. New optics and state of the art software, based on machine learning, enable to improve the resolution and the recognition of the extraneous matter (EXM). Today the combination of high-resolution optics, thin web and proper illumination make Neps, SCF, Barks, Grass and Trash recognizable and gradable in a very short cycle time.

70 selected cotton samples, which were pre-classed for EXM, were tested by CONTEST[®]. The results show that mass testing of EXM is possible. There is a good correspondence between the classer evaluation and the instrument for both Barks & Grass and SCF. Future grading for different levels of EXM could be developed in the next years by testing a large number of samples in order to upgrade the classification made by the instrument. Such experiments could lead to the elimination of the manual testing of EXM; the only operation which is still done manually by the classer.

From the spinners' point of view this could be an important piece of news since extraneous matters are still a big problem for the processed cotton leading to reduced spinning efficiency, increased raw material loss and higher number of yarn imperfections.

Since Neps are also included in the new algorithm, CONTEST[®] can be used in order to achieve complete quality control of the spinning process.

NEW FEATURES OF CONTEST[®] AND FIBERMAP[®]

Savio group is a network of companies, combining qualified technologies in the textile industry. Few years ago, a new project was started by Mesdan Spa and Loepfe Brothers Inc in the field of laboratory quality control of yarn and fibre.

The scope of the fibre project was to develop rapid and reliable instruments for the evaluation of the raw cotton and the control of the preparation process.

Two instruments based on the same technology have been designed in order to meet the different requirements of the cotton industry in terms of fibre quality control and determination of non-lint content.

Labmaster FIBERMAP[®] evaluates all the attributes known from the cotton classification (strength, length, uniformity, colour grade, leaf grade, trash, micronaire) and simultaneously analyses neps, seed coat fragments, trash, barks, grass, stickiness and maturity.

CONTEST[®] analyses neps, seed coat fragments, trash, barks, grass, stickiness in addition to fibre micronaire and maturity.

The last two years were dedicated to testing the performance of both CONTEST[®] and FIBERMAP[®] (figure1) in different commercial sectors. Producers, merchants and spinners tested more than 10,000 commercial cotton samples. Both Instruments performed with stability, accuracy and required low maintenance.

Additionally, an intensive R&D activity is conducted to improve the machine algorithm based on customers' and researchers' feedback.

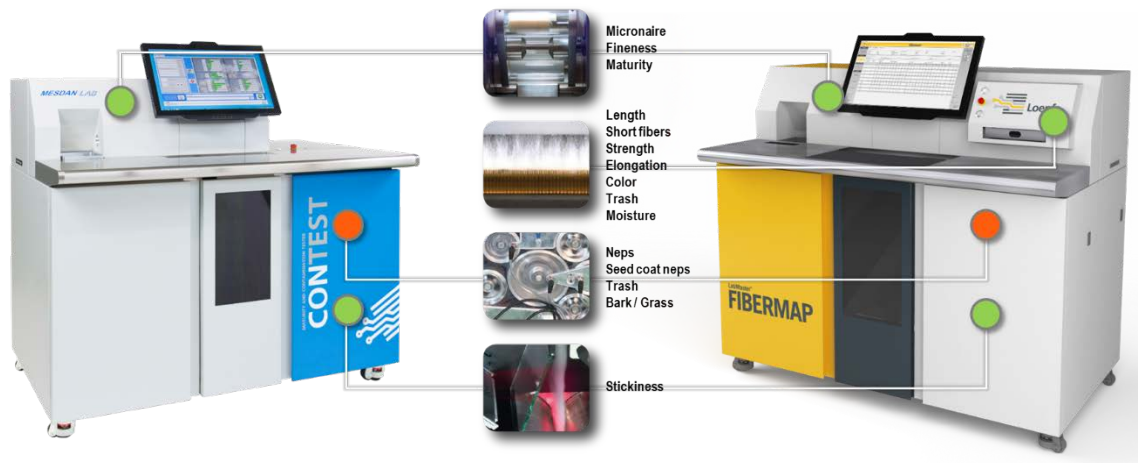


Figure 1: Testing features of CONTEST[®] and FIBERMAP[®]

In this regard, a totally new software was developed in order to provide a detailed classification of the so called Extraneous Matters ("EXM") mainly Bark, Grass and Seed coat fragment.

In spite of dramatic changes in the software, the instruments' technology for measuring neps and the non-lint content remains the same.

A 3.5 gr. sample is carded into ~ 10 meter of thin web which is image analysed by high resolution optics in order to spot and classify neps, leaf and EXM content. Subsequently a laser system counts and classifies the stickiness points remained on the surface of the two heated pressing rolls. The carded material is then recollected for double compression maturity test (figure 2).

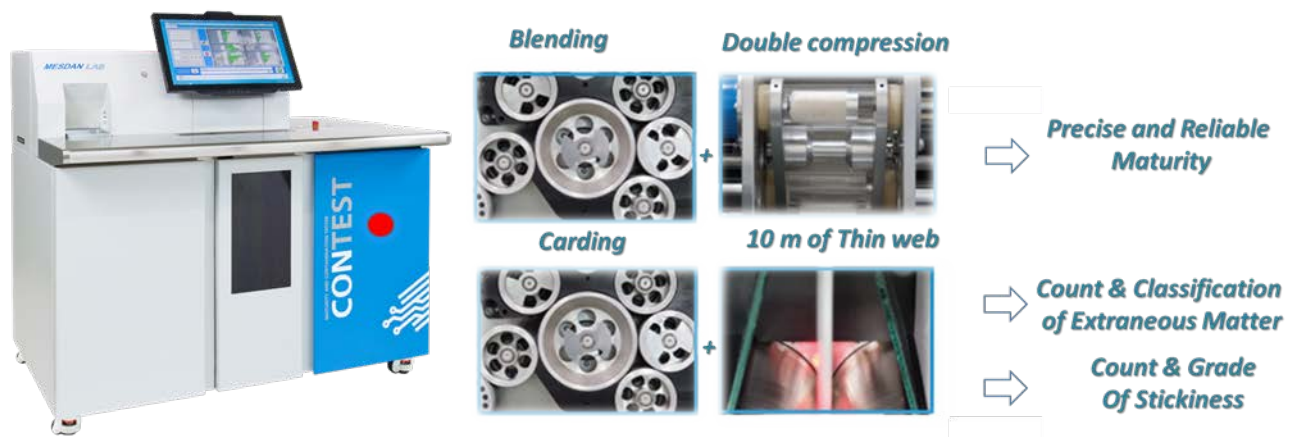


Figure 2: The principles of CONTEST® testing features

NEW IMAGE ANALYSIS TECHNOLOGY FOR TESTING NEPS AND EXM BASED ON MACHINE LEARNING

Extraneous matters and especially barks are not a new problem for the textile industry but its concern has increased with the industry's emphasis on quality fibres and growing speed of the spinning machinery. In 1992 Ethridge at al. ⁽²⁾ already showed the consistent increase of cotton processing costs due to high bark content mainly with ring spinning and less with open-end. Shurley at al. ⁽¹⁾ analysed classing data and showed significant increase of the Bark problem between the years 2010-2013 (see figure 3). All those research works convinced the cotton industry of the necessity to give special classification to extraneous matter. Nowadays the EXM classification is conducted as routine procedure and it is part of the standard cotton classification conducted by USDA. EXM is manually classed by trained classers who give an indication on the type of extraneous matter present in the cotton sample as well as an evaluation of its amount (light or heavy).

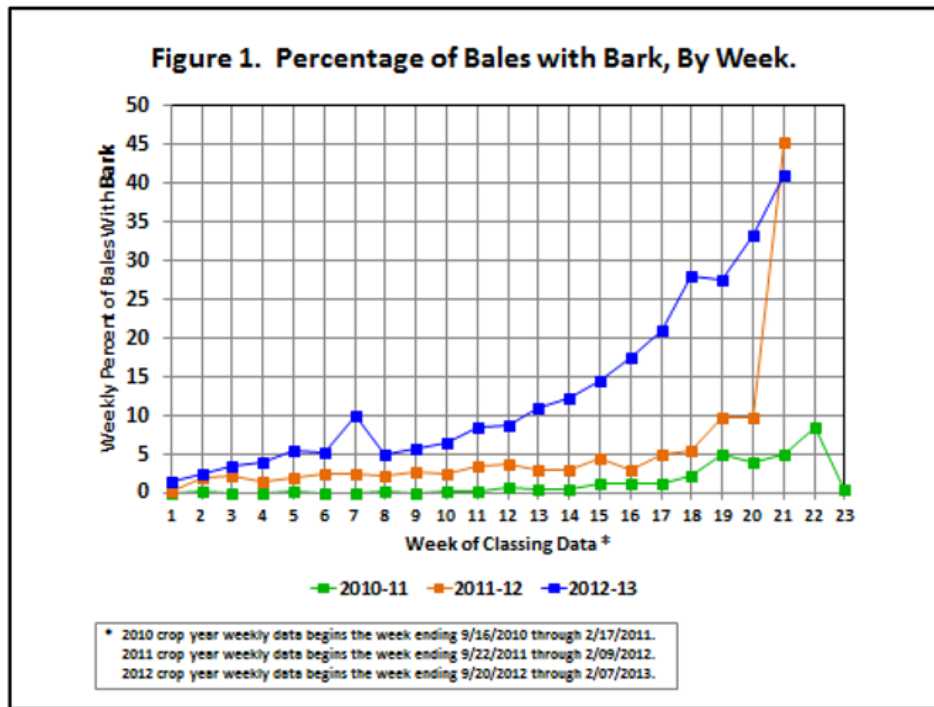


Figure 3: Percentage of bales with barks by week (source: Shurley at al. (1))

Savio group decided to address and confront the challenge of mechanizing this evaluation and classing of EXM as a part of their policy of serving as best as possible the need of quality control in the cotton textile industry.

Subsequently a totally new software was developed for CONTEST[®] and FIBERMAP[®] in the last two years. This software provides the operator with an accurate indication on the different types of extraneous matter present in the cotton sample such as Bark, Grass, Leaf and SCF particles. In the past there was no distinction and all the non-lint material was classified as Trash.

This distinction was achieved by using a higher resolution black and white camera, better optics and above all converting the old algorithm into a state of the art artificial intelligent software (AI) based on machine learning. Machine learning logic has an advantage with respect to a fixed algorithm since it enables the developers to define new attributes and teach the software how to distinguish between the different types of extraneous matter.

This process couldn't be started without having proper material to test. A selection of various samples classed for different EXM levels (i.e. Bark level 1, Bark level 2, SCF 1 and SCF 2) were kindly provided by USDA AMS Memphis.

An example of the different kinds and levels can be seen below (figure 4).



Figure 4: Different level of EXM (Bark, Grass and SCF) extracted from USDA samples

These samples were tested by CONTEST® in 2 operational modes, offline and online. Offline means running a standard CONTEST® sample and recording all its video frames (~ 100 frames per sample) for future analysis and re-calibration. Online means running standard CONTEST® sample and collecting the results without recording its frames.

A demonstration of the resolution achieved by the new optics and algorithm is shown in figure 5. Barks/Grass (when present) are clearly recognisable by their length and size distribution. The images in the first row refer to the recognition of Barks, Neps and Seed Coat Fragment by CONTEST® new algorithm, whereas the images at the bottom show the nature of the same kind of EXM (not the same ones) tested by an electron microscope.

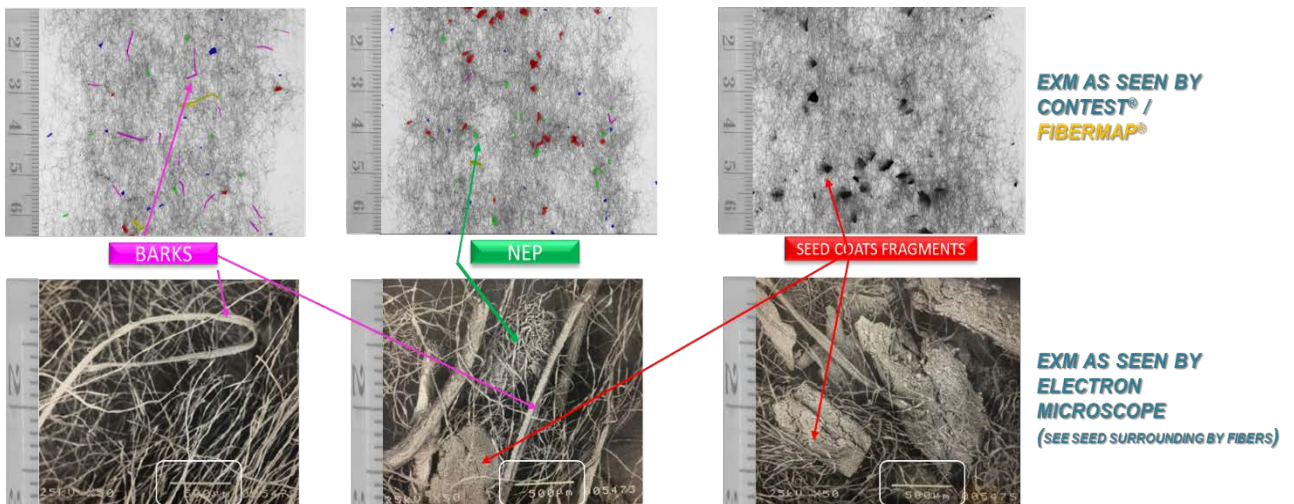


Figure 5: Top images refer to the recognition of different EXM by CONTEST®, whereas bottom images show the nature of the impurities by an electron microscope.

More detailed pictures of impurities in cotton are shown in figure 6 below. On the left it is shown a typical picture of Bark Level-2 sample (the highest in its category), taken during a standard test by CONTEST® (one frame out of a ~100). On the right it is shown a typical picture of SCF Level-2 sample (the highest in its category).

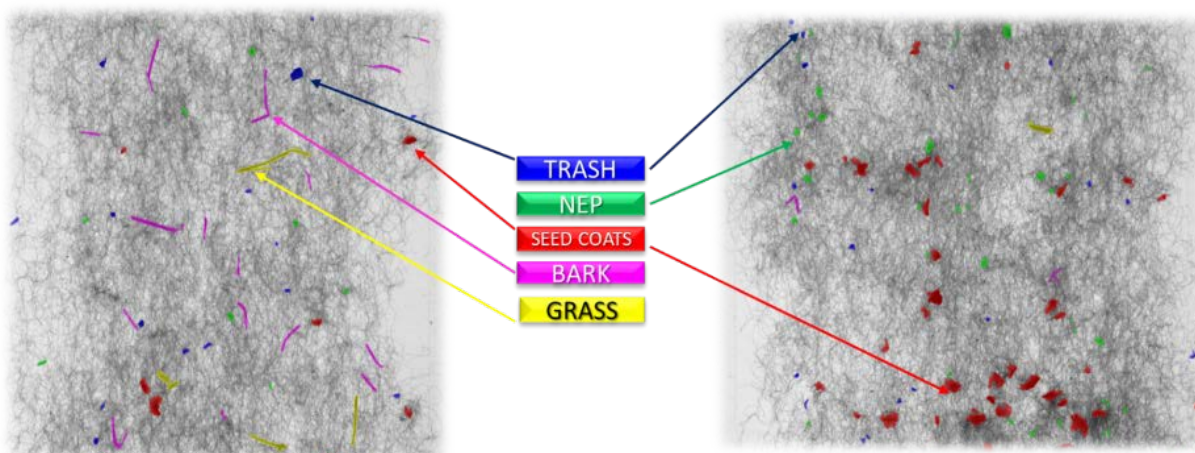


Figure 6: Recognition of Bark, Grass, Nep, Trash /leaf, SCF classified by the new algorithm.

The first step in order to make a classification based on digital image analysis is a clear definition and distinction among different impurities.

Therefore, an artificial transparent slide was prepared with all kind of EXM (barks, grass, SCF, trash/leaf and neps as well). Impurities of different size were laid, manually, on a piece of cotton web produced by CONTEST[®].

The result of this procedure is shown below (figure 7).



Figure7: Bark, Grass, Nep, Trash (leaf) and SCF visualized on white background.

This picture was taken with front light and white background in order to show the slide. Obviously, in this case it is very difficult to recognize white particles (Neps) on the left side of the slide.

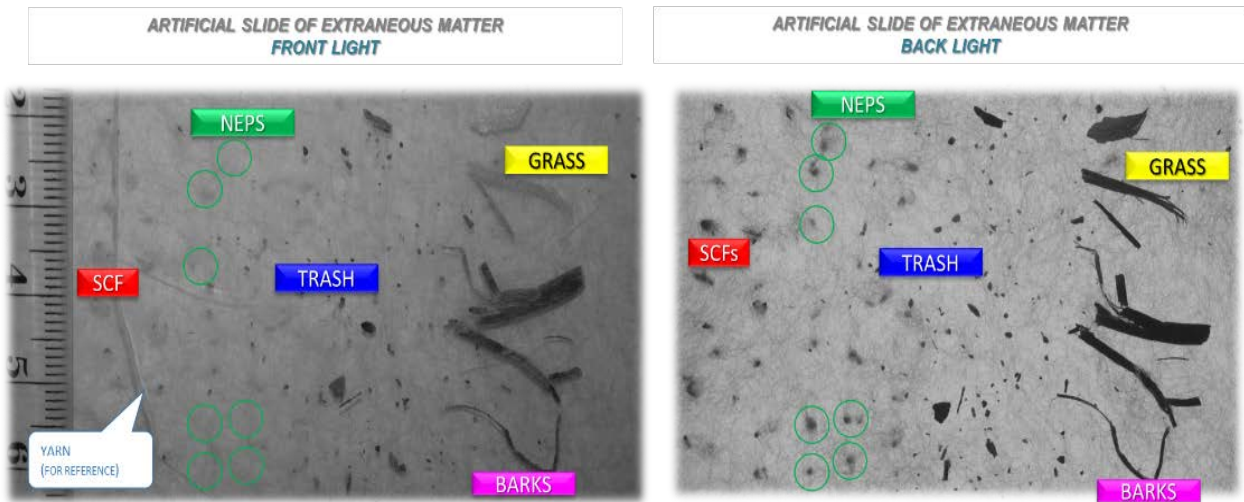


Figure 8: Bark, Grass, Nep, Trash (leaf), SCF visualized under front light and back light.

The transparent slide was introduced into the optical system of the instrument, in the same backlighted position of the cotton web. One of the images taken is shown above on the right of figure 8.

The picture of the artificial slide taken with front light and white background (on the left of figure 8) further demonstrate the difference between front and back light. Comparison with the image taken by CONTEST[®] emphasizes the distinction between neps and SCN. The ruler on the left gives a visual indication of the high resolution achieved.

It is clear that back light has advantage with respect to front light in a better recognition of the different kind of impurities. The contrast of Bark and Grass on a cotton web is much better, and the appearance of SCF versus nep is totally different since both of them consist of fibres but only the SCF includes a black core (the seed part).

The software classification of the image taken for the artificial slide by the optical system of CONTEST[®] is shown below in figure 9. Although many of the particles are tiny (see as a reference the ruler in figure 8), they are clearly spotted by the high resolution optical system, which provides enough pixels to ensure reliable pattern recognition by the new algorithm.

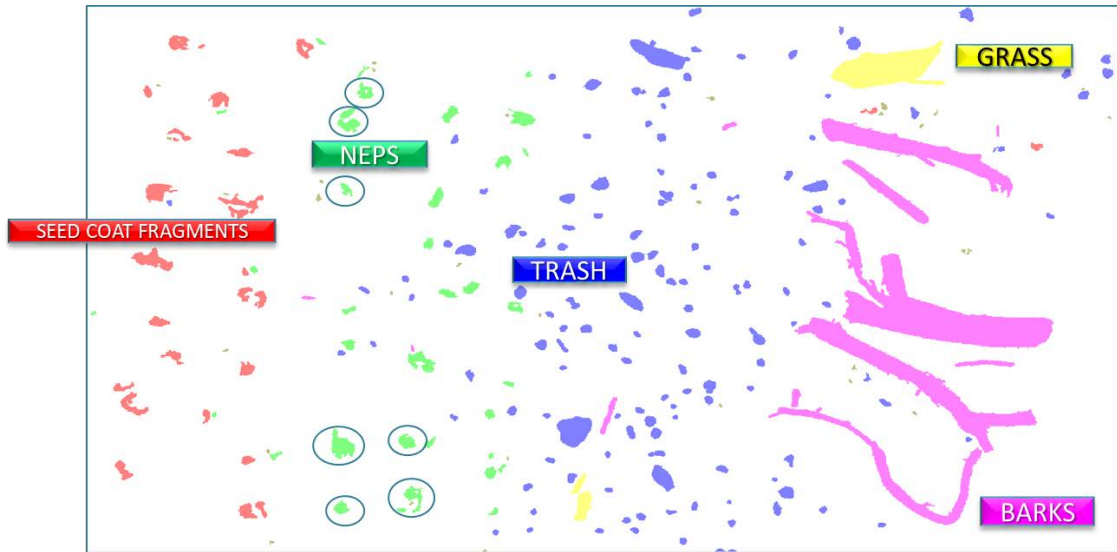


Figure 9: Artificial slide of Bark, Grass, Nep, Trash/leaf, SCF classified by new algorithm

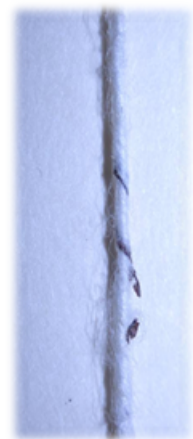
THE IMPORTANCE OF TESTING EXM FROM SPINNER’S POINT OF VIEW

From the spinners’ point of view, cotton containing EXM should not enter their warehouses. Bark, Grass and SCF are considered among the worst EXM since they cannot be easily removed thus increasing the cost of cleaning the cotton. In case they escape the cleaning process they can increase the breaks in the yarn during spinning and they can cause defects in the final product (Etridge at al.²).

According to the latest ITMF contamination survey (³), during the last 15 years SCF remained a problem for about one third of the processed cotton (higher than stickiness) as it is indicated in figure 10.

Summary 1989-2016					
Year	Degree of Contamination (%)			Stickiness (%)	Seed-coast fragments (%)
	Non-existent/insignificant	Moderate	Serious		
1989	86	9	5	21	0
1991	85	11	4	27	34
1993	85	11	4	26	36
1995	82	13	5	20	39
1997	82	13	5	23	32
1999	79	15	6	20	38
2001	78	16	6	18	40
2003	73	18	8	21	44
2005	78	15	7	17	37
2007	78	15	7	21	37
2009	78	16	6	13	27
2011	77	16	7	20	38
2013	73	18	8	23	42
2016	77	18	5	16	32

Source: ITMF contamination survey 2016



Bark in yarn

Figure 10: Degree of contamination by SCF and piece of bark into the yarn.

Therefore, the need for the best evaluation of EXM in cotton remains a technological challenge which has been addressed and solved both by CONTEST® and FIBERMAP®. It is crucial to detect Barks, Grass SCF (and Neps), because they are more difficult to remove than Leaf thus making the cotton cleaning process costlier.

RESULTS OF TESTING EXM BY CONTEST®

The best source of samples contaminated by EXM is USDA since their routine classing operation includes the evaluation of EXM. Therefore, it was our first task to examine samples which were found to have EXM according to USDA classing definition and to examine how CONTEST® new algorithm reacts to the different levels of the EXM.

Two sets of samples (2015 and 2017) were tested in order to define a correspondence between the level of EXM manually and visually indicated by USDA classers (Trace, Level 1 and Level 2) and the real number of particles found in the same samples by CONTEST® and classed as Barks & Grass and SCF.

It has to be outlined that USDA definition of the difference between Grass and Barks is not very clear. Therefore, at this stage of development, although Barks and Grass are counted separately by the instrument, they are graphically shown one on the top of the other so that the reader can see them together. It can also be that there isn't an exact definition of the different damage caused to the spinning process by Barks or by Grass. Most likely they behave the same being both long, fibre oriented and full of tiny hooks catching the fibres.

The results of samples 2015 and 2017 are shown in figures 11 and 12 respectively.

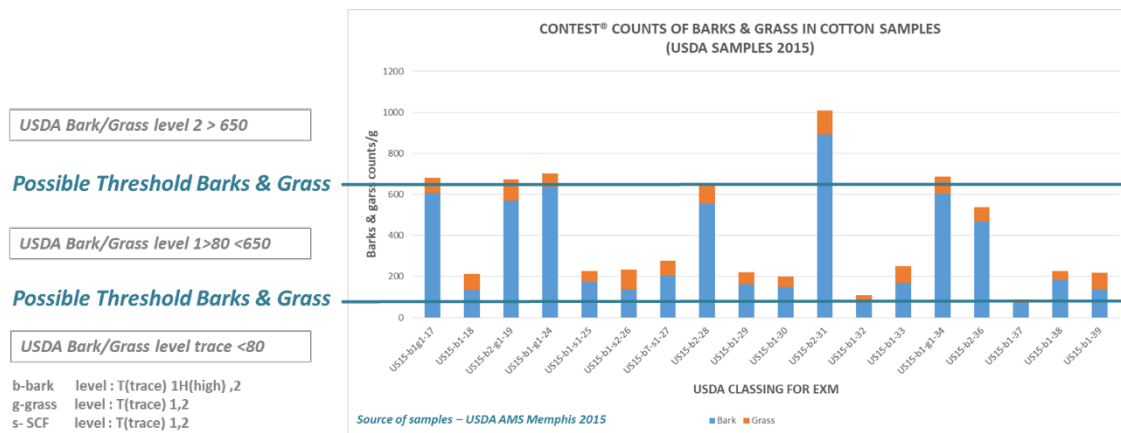


Figure 11: CONTEST® results for samples with different Bark and Grass levels (2015).

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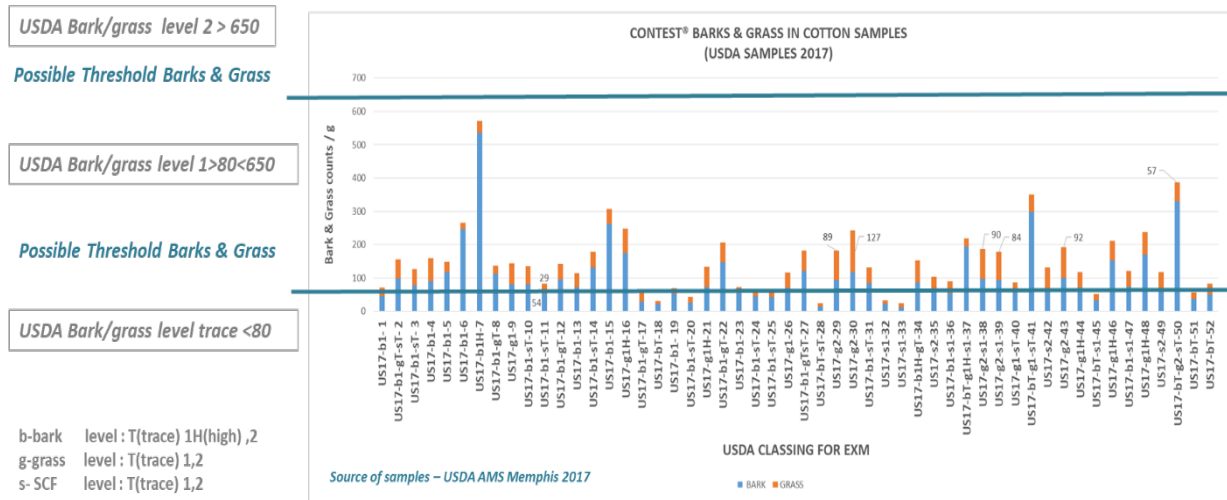


Figure 12: CONTEST® results for samples with different Bark and Grass levels (2017).

CONTEST® counted higher contents in samples marked “Bark Level 1 High” & “Bark Level 2” as well as in the ones called by the classer for a combination of Bark and Grass like “Bark Level 1+Grass Level 1” samples.

Furthermore, although the difference in the visual definition of bark and grass is very narrow, for most of the samples called “Grass Level 2” by the classer, CONTEST® showed higher counts of Grass particles (i.e. figure 12 sample 29,30,38,39).

The above experiments clearly show that mechanizing the evaluation of EXM is possible by means of the original technology of CONTEST® and FIBERMAP® thus adding this attribute to the others commonly used for cotton quality classification.

The very limited number of samples which were tested are not enough for grading the EXM content but it offers a very rough idea of a possible threshold based on the matching between the machine readings and USDA categories (Trace, Level 1, and Level 2).

The possible thresholds could be:

Trace = Count <80, Level 1 = Count >80 < 650, Level 2 = Count >650

Corresponding area could also be measured and therefore the percentage area could be calculated adding also this attribute to the EXM classification.

These levels will surely be changed while doing more calibrations and testing more samples in order to have better statistical analysis. However, it will not change the fact that there is a good consent between the subjective evaluation of the classers and the objective data of the machine. The data are low in “Trace” level, higher in “Level 1” and much higher in a combination of high bark and grass content or when “Level 2” is indicated. The exact thresholds will be defined as a result of a systematic

grading process for extraneous matter that will be conducted in future, similarly as done for the definition of the Leaf grade in the past.

The same logic also applies to Seed Coat Fragments. As shown below in figure 13 there is full correspondence between the instrument and the classer for sample with SCF Level 2 (see red bars in the graph). However, for level Trace and Level 1 can't be defined since there is no consistent match between the classer evaluation and the instrument data. The possible thresholds are only a mere indication since CONTEST[®] counted less than 90 for most of the samples which were not noted by the classer for SCF (see the blue bar in the graph), whereas for few of them the count was much higher (i.e. samples 13,15,18,19 and 23). Maybe one possible explanation is that the SCF counted by CONTEST[®] are too small to be felt by hand. However, a larger number of samples and detailed analysis will be required to come to a conclusion.

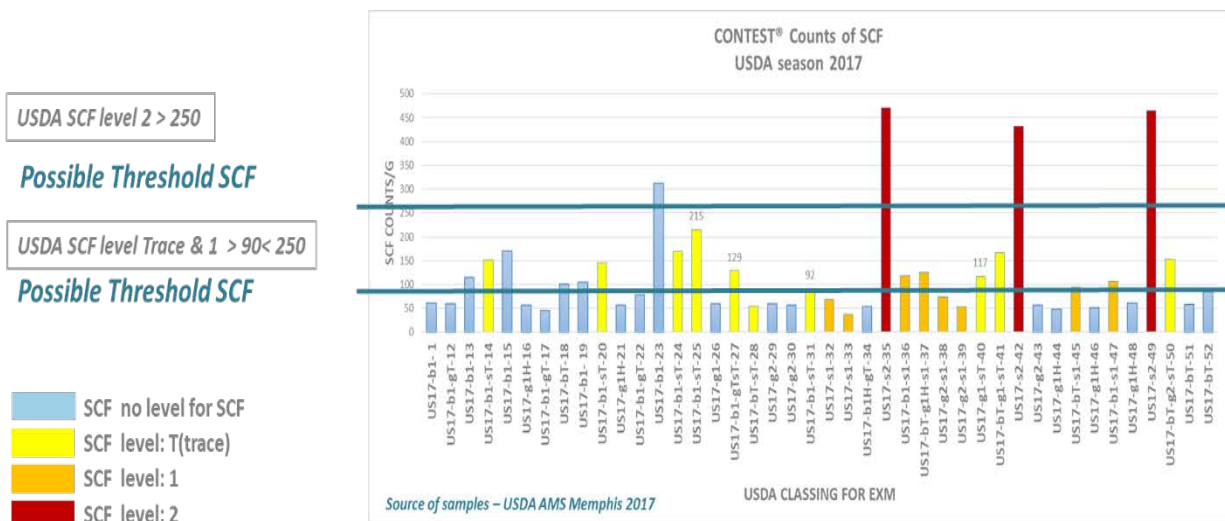


Figure 13: CONTEST[®] counts of samples of different SCF levels (2017).

Finally, we want to remember that Neps are also a part of the parameters that CONTEST[®] and FIBERMAP[®] can test at same cycle while testing EXM.

SUMMARY AND CONCLUSIONS

CONTEST[®] and FIBERMAP[®] are multitasking testers which test many parameters which are useful for improving the performance of the cotton textile industry.

The aim of this article was to enlighten the new features of CONTEST[®] and FIBERMAP[®] which are not available in the market.

Extraneous matter causes loss and quality reduction in the entire cotton production chain. It is a known and current problem; however, it is still the only cotton quality attribute that is manually classed.

It was shown that CONTEST[®]/FIBERMAP[®] new high-resolution optics and state of the art machine learning algorithm, enable classification of cottons based on the EXM content (Bark, Grass, SCF, Leaf, Trash). The way of how the industry will embrace this state of the art technology is for the industry to decide, but the technology exist.

Thresholds for different types of EXM attributes should be defined by the cotton and textile community in order to enable better communication between producers and spinners regarding EXM.

CONTEST[®] and FIBERMAP[®] are high speed instruments that can be used by spinners for cotton layout selection based on the content of neps, barks/grass and seed coat fragments.

ACKNOWLEDGMENTS

- To USDA AMS Memphis. Special thanks to Jimmy Knowlton for providing samples with high and low content of extraneous matter
- To USDA ARS New Orleans. Special thanks to Chris Delhom for testing the USDA samples provided by the USDA AMS.

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