# Up date on Cotton Stickiness Measurement

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## ABSTRACT

*Different stickiness measurements were used to determine the statistical variability of stickiness in bales contaminated by aphids and white flies to establish an effective bale sampling procedure for estimating the degree of stickiness.*

## Introduction

Since 1997, the International Textile Center (ITC) has been engaged in a collaborative research effort aimed at developing reliable measurements for stickiness of cotton fibers, in order to enable efficient management of this contamination problem. The results of work done so far provide encouragement that sufficiently fast and repeatable measurements of stickiness will be possible in the months ahead. Critical partners in this project are Cotton Incorporated in USA, the Cotton Program of CIRAD in France, and the Cotton division of the Agricultural Marketing Service, U.S. Department of Agriculture. Contributions and logistical support have come from several other sources; including participation by the Arizona Cotton research and Protection Council (ACRPC), in Tempe, Arizona. This update on cotton stickiness measurement summarizes some of the major results obtained so far and plans for obtaining further results.

## Procedures

In 1997, fifty bales were selected by PCCA (Plains Cotton Cooperative Association, Lubbock - USA) to get a wide range of stickiness due to aphid (*Aphis gossypii*) infestation. Within these bales, eleven were bales coming from one module.

In 1998, fifty bales from Arizona and fifty bales from California were selected by Calcot (Bakersfield, California) to get a wide range of stickiness due to white fly (*Bemisia tabaci*) infestation. Within the California bales, 23 were bales coming from one module.

The bales were broken and layered. Ten samples were taken from each bale. Each of these samples was divided into sub-samples, one was sent to CIRAD (Centre de Coopèration Internationale en Recherche Agronomique pour le Dèveloppement, Montpellier – France), one to Cotton Incorporated (Raleigh – USA), one to USDA AMS (United States Department of Agriculture, Memphis – USA), one to ACRPC (Arizona Cotton Research and Protection Center, Tempe – USA).

On the Texas cottons, stickiness data were collected from the following instruments: HPLC (High Performance Liquid Chromatography), Card, FCT (Fiber Contamination Tester) in two locations, H2SD (High Speed stickiness Detector) in two locations, SCT (Sticky Cotton Thermodetector) in two locations. On the Arizona cottons the HPLC data are already available. The other tests will be done on both Arizona and California samples before the end of the year.

## The HPLC results

The 1000 samples were run with an HPLC to identify entomological and physiological sugars on the cotton lint. The following sugars were detected: inositol, trehalose, glucose, fructose, threhalulose, sucrose and melezitose. A high percentage of melezitose reveals the presence of aphid honeydew, whereas with both melezitose and trehalulose present and trehalulose being dominant indicates white flies. For the Texas bales the trehalulose content ranges between 0.001% and 0.075% of the sample weight and the melezitose content between 0.008% and 0.113% of the sample weight. This means that all of the bales were contaminated by insect honeydew, to some degree. Figure 1 shows that the melezitose is in general the dominant sugar except for 13 bales (including 11 coming from one module). In these bales we found significant amounts of both trehalulose and melezitose. The percentage of the total sugars is around 10 percent for both types of sugars. It means that we probably have in this area a contamination coming from white flies and possibly from aphids. Hendrix (1992), analyzing honeydew from Aphis gossypii and Bemisia tabaci found around 40% of melezitose in the aphid honeydew and 40% of trehalulose plus 17% of melezitose in the white fly honeydew. We have found lower percentages of these sugars in our bale samples which suggests that we had a high content of physiological sugars, i.e. stickiness from plant sugars.

For the Arizona bales, the trehalulose content range between 0.005% and 0.510% and the melezitose content between 0.024% and 0.280%. This means that all of the bales were contaminated by insect honeydew. The trehalulose percentage averaged 7.2 times higher in Arizona bales than in Texas bales, while the melezitose content it is 2.8 times higher (Figure 2). Figure 3 shows that melezitose and threhalulose together are, except for 13 bales, the dominant sugars (62% of the total sugars excluding the 13 bales). Such results reveal white fly contamination. In the fore mentioned 13 bales we found a high percentage of melezitose (around 25%) and a low percentage of threhalulose (around 10%): therefore, in addition to the white fly infestation, this area probably had a contamination coming from aphids, too.

The presence of trehalulose and melezitose reveals contamination by insect honeydew, but is it a predictor of stickiness? The only measurement available for both locations at the present time is the card test. Figures 4 and 5 show the relation between threhalulose and card grade (the relation melezitose-card grade is very similar). The coefficient of correlation is quite good for the Texas cottons (r = 0.755) and extremely good for the Arizona cottons (r = 0.948), suggesting that the trehalulose content could be a candidate for predicting stickiness. Unfortunately, Figure 6 shows the relationship card-trehalulose for both types of cottons (Texas and Arizona) and it appears that these relations are clearly different. This leads to the conclusion that the HPLC cannot be a good predictor of stickiness. Apparently the stickiness potential of a cotton is not only linked to the percentage of a specific sugar, but to the balance between the various sugars as well.

## The variability within a bale

Due to the Poisson-like distribution of the stickiness measurements, analyses were performed using a square root transformation.

Figures 7 to 15 show the variability and level (average + or – two standard deviations) of stickiness measurements within bales. Point estimates were determined by averaging replicated measurements (3 on both FCTs, 2 on Cotton Inc. H2SD, 3 on CIRAD H2SD, 3 on CIRAD SCT, 4 on ACRPC SCT).

For the ITC-FCT (Figure 7), variability was too great to distinguish among bales. But the USDA FCT (Figure 8) was clearly able to make such distinction. Eleven of the bales (numbers 32 to 42) came from a module and they are easily recognizable with this instrument. A chart of the differences between average values (Figure 9) obtained at ITC and USDA verifies that there was no agreement between the two FCT instruments. The ITC measurements were consistently higher than the USDA measurements on everything except for those bales in the module, where the ITC measurements were consistently lower. This non-random distribution of the differences suggest that one or two of the main setting parameters of the FCT, i.e. crush rolls temperature and pressure applied on the card web by the crush rolls, were inadequate on the ITC machine. In addition, some false-positives, resulting from a residual contamination of the instrument, were detected and confirmed by further investigations.

For the H2SD, the CIRAD instrument (Figure 10) appears to have performed better than the Cotton Incorporated instrument (Figure 11). For the Cotton Incorporated H2SD, the variability of the average for each bale is acceptable but the variability of the individual results is too high, especially for bales 9 to 11. For the CIRAD H2SD, the results are extremely good for both the average level and the individual readings. It confirms the USDA FCT results. The chart of differences between average values at CIRAD versus Cotton Incorporated (Figure 12) verifies that agreement between these two machines was quite good.

For the SCT (Figure 13 to 15), the results are quite good for a manual instrument. A few bales exhibited large variability with the ACRPC thermodetector, but the range for most of them is acceptable. For the CIRAD thermodetector the variability within a bale is at a very low level, perhaps reflecting the impact of experienced and conscientious operators. Charting the differences between average values at CIRAD and ACRPC verifies that agreement between these instruments was good, but not as good as with the H2SD. Nevertheless, the distribution of the differences is not random. All the bales from the cotton module are well below the zero axis. The combination temperature-pressure is very critical for the SCT. Since the temperature is electronically controlled on this instrument, the cause of the differences is probably a lower pressure on the ACRPC instrument. This could suggest that different sugar compositions could react differently to differences in pressure.

## Relations between the measurements

The simple correlation matrix given below, based on averages of each bale (50 observations), shows that the ITC FCT is very poorly correlated with all the other instruments. The best correlation is obtained between the USDA FCT and the CIRAD H2SD.

Figure 16 shows results of regressing Cotton Incorporated average values from the H2SD on CIRAD average values for the same instrument. The slope and offset are very close from one and zero respectively. The coefficient of correlation is quite good (r = 0.91), but it is to be hoped that this value could be raised to 0.95 or higher.

Figure 17 shows the relationship between the two SCT's. The slope and offset are far from what we hoped with respectively 0.551 and 1.995. The low readings with the ACPRC SCT, especially for the very sticky cottons, could be due to a low pressure during testing combined with an operator effect. If calibration cottons were available, a calibration procedure should enable making the slope and intercept terms approximate one and zero. Nevertheless, a correlation of 0.93 between two manual instruments was unexpected.

It is a pleasant surprise that the coefficient of correlation obtained by regressing CIRAD measurements with the H2SD on the USDA measurements on the FCT reaches 0.97 (Figure 18). The slope and intercept terms are not close to one and zero, but this was expected since the two machines employ different techniques in measurement. A sufficient condition for the number of sticky spots to be larger on the FCT is the fact that this instrument utilizes a much larger surface of cotton fibers than does the H2SD. Nevertheless, given high correlation levels between the two instruments it is possible, with the use of appropriate calibration cottons and procedures, to develop a functional correspondence between them.

## Conclusion

The results of the work done so far give encouragement that fast and repeatable measurements of stickiness will be possible in the months ahead. Both FCT and H2SD have the potential to provide reliable results at a speed compatible with the bale classification.

The correlation between the CIRAD H2SD and the USDA FCT reach an unexpectedly high level for this type of instrument; the coefficient of determination was 94%. Nevertheless, the natural variability of stickiness is quite important and reaching a level of repeatability compatible with the needs of the industry will likely require at least two samples per bale. However, an evaluation of repeatability of stickiness measurements using module averaging and two measurements per bale (one on each side), indicated repeatability of 85% for the FCT and 90% for the H2SD. If we can confirm these results, it will mean that the commercial classification of stickiness is possible.

The short term and long term stability of the results should be addressed, particularly calibration procedures and operating routines. In addition, work needs to be initiated in order to investigate the origin of the differences between instruments, then to find ways to alleviate this problem in the future.

**Correlation matrix on 50 bales.**

| | FCT ITC | H2SD Cot. Inc. | SCT ACRPC | FCT USDA | SCT CIRAD | H2SD CIRAD |
|---|---|---|---|---|---|---|
| FCT ITC | 1 | | | | | |
| H2SD CI | 0.30 | 1 | | | | |
| SCT ACRPC | 0.12 | 0.79 | 1 | | | |
| FCT USDA | 0.24 | 0.90 | 0.87 | 1 | | |
| SCT CIRAD | 0.10 | 0.84 | 0.93 | 0.93 | 1 | |
| H2SD CIRAD | 0.29 | 0.91 | 0.87 | 0.97 | 0.91 | 1 |

**Figure 1. Melazitose and trehalulose within the 50 Texas bales.**

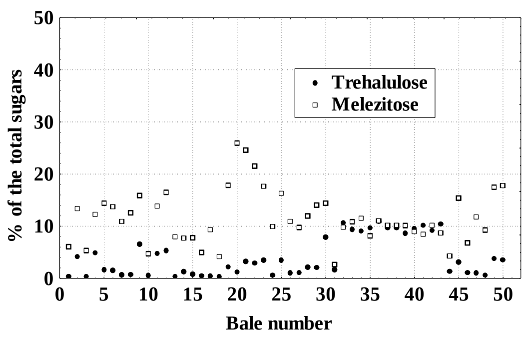


**Figure 2. Melazitose and trehalulose content.**

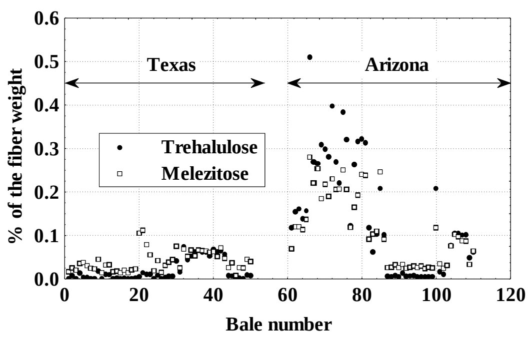

**Figure 3. Melazitose and trehalulose within the 50 Arizona bales.**

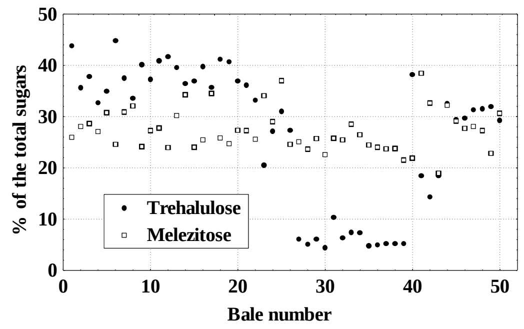


**Figure 4. Card vs trehalulose Texas cottons.**

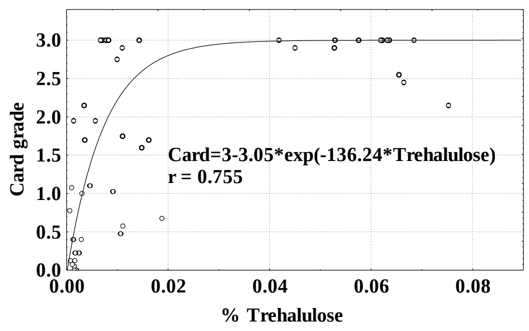


**Figure 5. Card vs trehalulose Arizona cottons.**

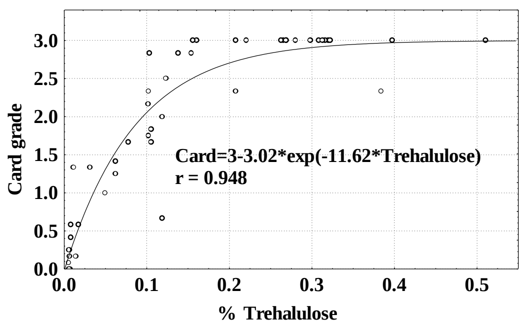


**Figure 6. Card vs trehalulose comparison Texas – Arizona.**

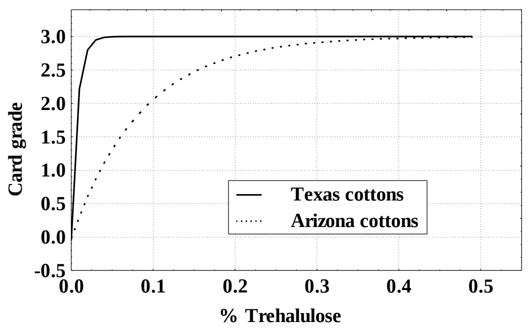


**Figure 7. FCT values at USDA. Average ±two standard deviations.**

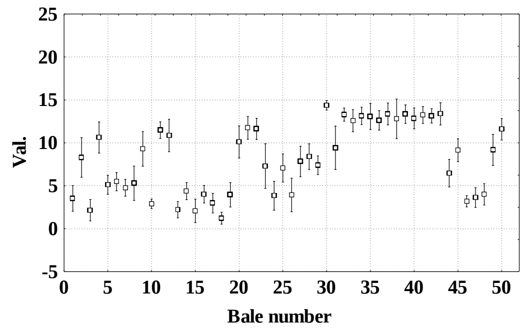


**Figure 8. FCT values at ITC. Average ±two standard deviations.**

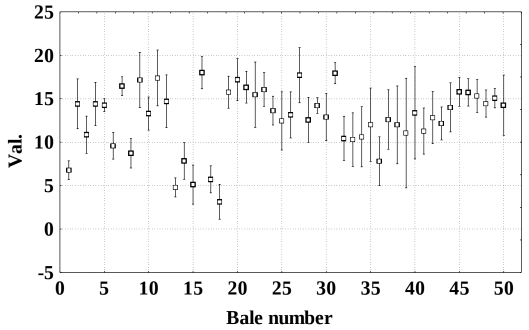


**Figure 9. FCT Differences (ITC-USDA).**

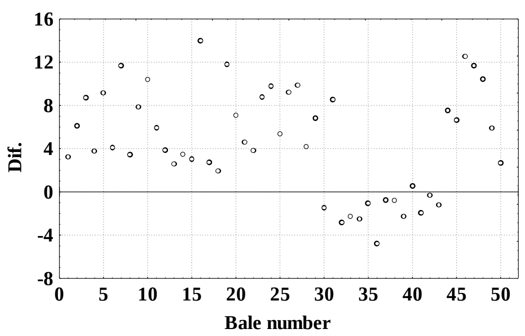


**Figure 10. H2SD values at cotton Inc. Averages ±Two standard deviations.**

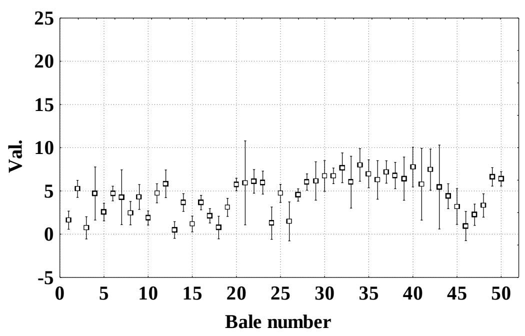

**Figure 11. H2SD values at CIRAD. Average ±two standard deviations.**

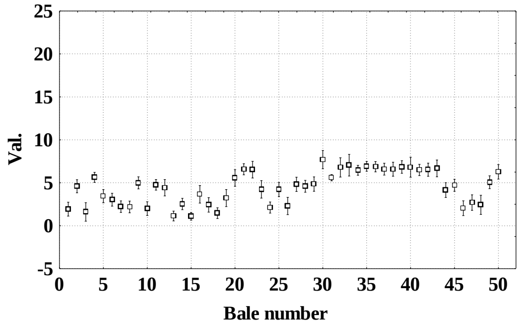


**Figure 12. H2S Differences (CIRAD-CI)**

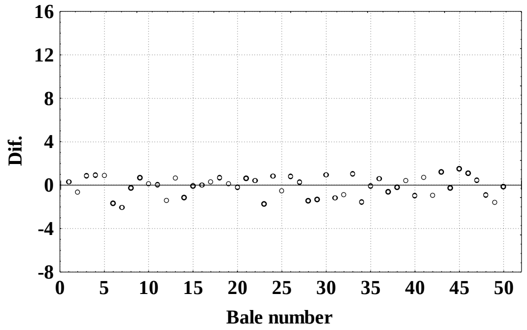


**Figure 13. SCT values at CIRAD, Average ±two standard deviations.**

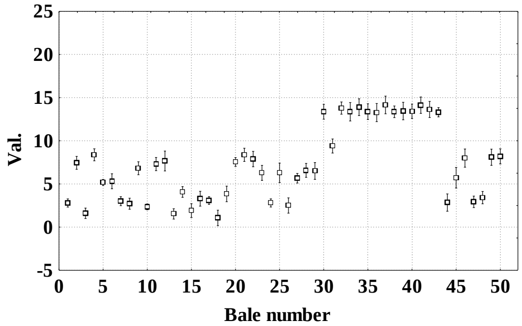


**Figure 14. SCT values at ACRPC. Average ±two standard deviations.**

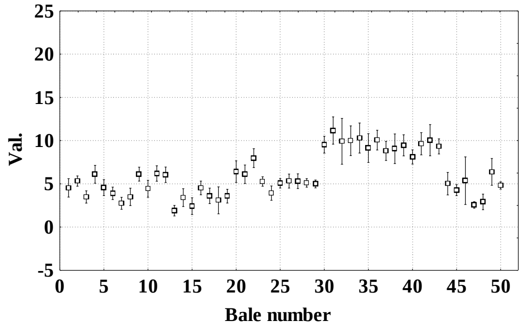


**Figure 15. SCT Differences (CIRAD-ACRPD).**

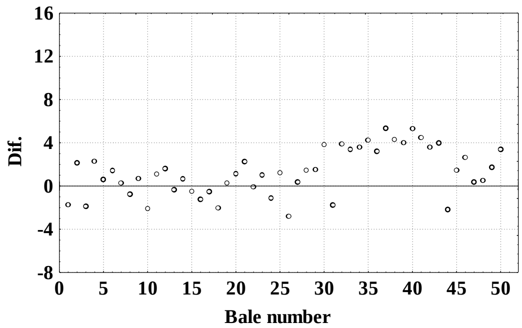


**Figure 16. Cotton Inc. H2SD vs CIRAD H2SD. Cotton Inc. – 0.042 + 1.013 * CIRAD.**

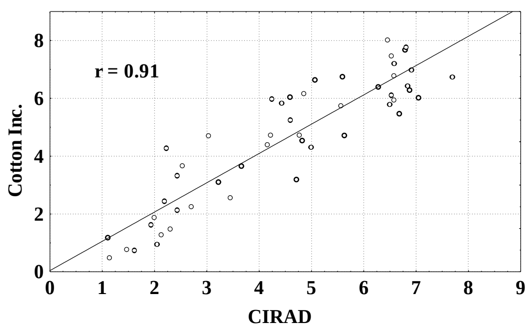

**Figure 17. ACRPC SCT vs CIRAD SCT.**
**ACRPC = 1.995 + 0.551 * CIRAD.**

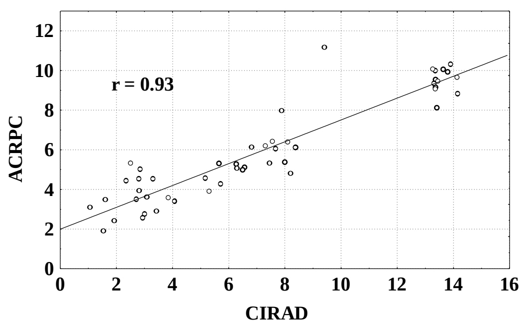


**Figure 18. CIRAD H2SD vs USDA FCT. CIRAD H2SD = 0.684 + 0.464 * USDA FCT.**