THE USE OF THE HIGH SPEED STICKINESS DETECTOR ON A LARGE RANGE OF COTTON COMING FROM DIFFERENT COUNTRIES

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Abstract

For some years now, all those involved in the cotton industry, from grower to spinner, have become increasingly concerned by the stickiness encountered during cotton-to-yarn processing, and have attempted to find a remedy. Unfortunately, even today it is very difficult to precisely identify producer countries affected by this problem as stickiness is governed by several factors which induce annual and spatial variations that modify its intensity. Also, no official system is yet available to classify this criterion. Furthermore, as this phenomenon has already produced marked economic effects, information concerning the origins of contaminated cottons it not always made available.

Introduction

It was at the beginning of the 1980's that certain spinners noted that the spinning process was substantially disrupted by sticky cottons. This stickiness can be caused by physiological sugars produced by the plant or by entomological sugars produced by insects.

Several authors have noted that physiological sugars cause stickiness during spinning:

Perkins (1971) reported that small groups of immature fibers were causing problems on the card web feeding rollers and that these cottons contained very high concentrations of physiological sugars. He noted that it is advisable not to use this type of cotton in spinning. This lack of maturity is also the origin of fiber neps formed by fibers tangling during machine processing. These tangles result in the production of poor quality yarn that shows a low dye affinity (Perkins and Bargeron, 1980).

Wyatt (1976) reported that sugar levels of 0.3 % or less did not cause any problems. He noted that when dealing with a low micronaire index, sugar levels may reach 0.8 %.

Entomological sugars are produced by insects excreting sugary substances, generally known as honeydew. This honeydew contaminates the fiber and can be found at each step of fiber processing, i.e. from the plant to the yarn (Héquet and Frydrych, 1992). The main producing insects are the aphid *Aphis gossypii*, the white fly *Bemisia tabaci*, and to a lesser extent the mealybugs *Ferrisia virgata*, *Nipaecoccus vastator* and *Phaenacoccus* (Couilloud, 1986). The report presented here only concerns the two main pests.

When on the plant, aphids and white flies live mainly on the inner surface of the leaves. They puncture the sap's descending circulation system, sucking out the sap as food. They excrete honeydew onto the leaves and onto the fiber of open bolls either in the form of a very fine spray of droplets (white flies) or in the form of large drops (aphids). Under certain conditions fungi are found growing on the honeydew (Hillocks and Brettell, 1993), forming fumagine. If large amounts of sugar are deposited onto the leaves, these form droplets that fall onto the fiber, causing substantial contamination. The ginning process disperses the honeydew thus rendering it difficult to detect by eye.

Cottons contaminated by insect-derived honeydew cause process disruptions from the ginning phase to spinning operations:

- When processed by saw ginning, the contaminated fiber deposits honeydew onto the teeth of the saw and sticks there (Delattre, 1973). Fibers clogged in the extractors prevent the air from being extracted. Both these effects require machine stoppage and cleaning. When studying roller ginning, Khalifa and Gameel (1982) reported output of 5 to 7 kg per gin and per hour, whereas output for clean cotton is 25 to 30 kg.

- During spinning, the honeydew attached to the fiber generally sticks to all items that exert pressure, i.e. the card rollers, those on the drawing frame, the brushes and the spinning assembly (Perkins, 1983-a; Gutknecht *et al.*, 1988; Perkins, 1991; Shigeak Izawa, 1992). This honeydew also contaminates the tables that feed rotor-spinning openers and can be found deposited within the rotors (Marquié *et al.*, 1983). These deposits cause the fibers to rise upwards, leading to irregularities in the card web and in slivers. This predisposes to breakages in the yarn and alters its quality. Machines must be stopped and cleaned at a frequency that depends on the extent of this contamination.

Numerous detection methods have been developed to measure stickiness and reduce its effects. The CIRAD technology laboratory has developed two thermomechanical methods for this detection: the SCT thermodetector and the high-speed H2SD. Both systems are presented here and have been used to measure cottons from various origins.

Methods and materials

Thermodetection method

Principle. This thermomechanical method (Frydrych, 1986) combines the effect of heat and pressure applied to a

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sample of cotton placed between two aluminium plates. The aluminium plates are inert to the test sample and provide rapid transfer of the heat. When the temperature increases, the cotton releases its water which is absorbed by the honeydew. This therefore becomes sticky. The honeydew contained within the cotton sample then sticks onto the plates. Pressure is then applied immediately at ambient temperature to fix the honeydew to the plates, and these spots can then be counted.

The cotton sample is processed at 65 % RH and at a temperature of 21/C. The following methodology is applied: a 2.5 g sample of cotton is opened on a manual opener to form a web with a density of 30 g/m5. This is then placed between two sheets of aluminium and the entire assembly is placed on the lower plate of the thermodetector and hot pressure is applied for 12 seconds. This is followed by pressure applied for 2 minutes at ambient temperature. The assembly is then left for one hour before the sticky points on the upper and lower sheets of aluminium are counted. The count is established as follows: the cotton web on the lower sheet of aluminium is removed. The plate is cleaned using a special non-woven cleaning pad impregnated with mineral oil. The sticky points on the two sheets of aluminium are then counted. The test is repeated three times per sample to determine the extent of the stickiness.

High-speed H2SD

The main advantage of the high-speed stickiness detector is that it can monitor and evaluate the stickiness of production batches. If no methods are available to monitor cotton, the entire production may be considered as sticky and its price will fall. The ultimate aim therefore is to pick out non-sticky cotton and also provide the user with a system to manage purchases and stocks.

The H2SD high-speed stickiness detector (Frydrych *et al*., 1994) presents the following advantages:

- human intervention in sample preparation and during stickiness evaluation is reduced to a minimum,
- the measurement is quantitative, giving a honeydew count,
- it is possible to determine the size of the sticky points,
- a result is obtained every 30 seconds.

Principle. The analysis is performed at 65 2 % RH and 21 1/C. A sample of cotton (about 3 grams) is opened using a rotor to form a mass with a density of about 160 g/m5. This is placed on an aluminium plate which passes successively in front of 4 stations. Hot pressure is applied to the sample. The combination of the water in the cotton and the temperature differential between the heat applied and the aluminium, produces a thin layer of wetness on the sheet of aluminium. The sticky points in contact with the plate are fixed in place by pressure exerted at ambient temperature. The cotton is then removed and the sticky points are evaluated by an image analyzer which counts the points and determines their size. Like for the thermodetector, three counts are made for each sample.

Results and discussion

1. Testing of 96 cottons on the CIRAD laboratory SCT thermodetector: relationship between mean and variance

Ninety-six cotton samples, with three replications, originating in different countries and saw-ginned were tested on the thermodetector. The intra-sample distribution of the number of sticky points was not normal. The data were therefore transformed before statistical analysis in order to stabilize the variances and normalize distribution (Dagnélie, 1975).

This choice was made after a diagram was constructed showing the dispersion of the means and variances on a logarithmic scale. Figure 1 shows the linear relationship between the mean and the variance, given by the equation:

Log (variance+1) = 1.046 x Log (mean+1) with r = 0.78

As the relationship between the mean and the variance was close to equality; the initial data were converted into square root values.

2. Validation at the Cotton Incorporated laboratory: mean-variance relationship

This mean-variance relationship was validated on the thermodetector at the Cotton Incorporated laboratory in Raleigh, testing 829 samples with 2 repetitions. Figure 2 shows a relationship close to equality, where:

Log (variance+1) = 0.97 x Log (mean+1) - 0.004 with r = 0.84

3. 96 cottons tested on the CIRAD H2SD high-speed detector

The 96 cottons already tested on the SCT were also analyzed on the H2SD with three replications. The relationship between the mean and the variance is illustrated in figure 3. This was:

Log (variance+1) = 0.986 x Log (mean+1) + 0.1 r = 0.77

Thus, the H2SD also gave a relationship between the mean and the variance close to equality.

4. Thermodetector and H2SD: Precision of the results as a function of the number of tests

In the studies described above, the parameters used to plot the curves were little different in practice from those valid for the Poisson law. The intra-sample distribution of the number of sticky points is very close to a Poisson-type distribution.

The precision of any measurement run is given by the confidence interval around the mean. If it is accepted that the number of sticky points follows Poisson's law, the confidence interval will be asymmetric. In cases of Poisson's law for parameter , the confidence interval around is determined by using the expression given below (Gozé, 1993, citing Saporta, 1990):

$$\frac{1}{2r}\chi^2_{(2rM;\,\alpha/2)} \le \lambda \le \frac{1}{2r}\chi^2_{2(rM+1);\,1-\alpha/2}$$

Where: r = number of measurements per sample
M = mean observed
λ = true mean
α = confidence level

Generally, we use the confidence limits for the expectation of a Poisson variable (Pearson and Hartley, 1976). For practical reasons we use a scale (figure 4, drawn up by Chaume and Chanselme, 1996) to give this interval as a function of the number of repetitions (1, 2, 3). Each mean observed on the x axis has a corresponding confidence interval of the "true" mean as a function of the number of repetitions per sample.

5. Relationship between SCT thermodetector and CIRAD laboratory H2SD

A very good relationship was obtained between the results for the 96 cottons on the thermodetector and on the H2SD as a correlation coefficient of 0.95 was observed (figure 5). The data were converted into square root values in order to meet the conditions required for linear regression. The regression coefficients were such that, by returning to the original scale, the number of sticky points detected by the H2SD were half the count obtained on the thermodetector, whereas the surface area counted was 8-fold less. This is due to the rotor opener which produces excellent quality contact between the aluminium plate and the sample.

6. Relationship between the SCT thermodetector and the CIRAD H2SD and the Cotton Incorporated H2SD

An H2SD has been installed at Cotton Incorporated in Raleigh. The first validation tests were conducted on a range of 42 sticky cottons of various origins (Africa, central Asia, USA, etc.). These cottons were tested on SCT and H2SD machines at CIRAD, then on the H2SD at Cotton Incorporated. The relationships (figure 6) between the results given by these three devices were very good as shown by the correlation coefficients below:

SCT and CIRAD H2SD $r = 0.95$
SCT and Cot. Inc. H2SD $r = 0.97$

Results obtained on the CIRAD H2SD and the Cotton Incorporated H2SD (figure 7) also showed a good relationship as the coefficient of correlation between these was 0.92. However, a slight difference was observed between the two machines, indicating that a procedure should be designed for their calibration.

7. Advantages of the high-speed H2SD detector

Like the thermodetector, the high-speed H2SD gives quantitative results. As the H2SD is entirely automated, it presents several advantages: it is fast as it gives a result every 30 seconds and its speed is similar to that shown by commercial HVI machines used for the bale-to-bale determination of cotton fiber characteristics. No operator effect is involved as the operator's role is reduced to feeding the machine. The sticky points are counted and sized by an image analyzer.

Tests conducted on the thermodetector give honeydew-fiber points of varying sizes, ranging from small honeydew deposits with a few fibers to very large deposits with a veritable tuft of fibers. It is obvious that, during spinning, these will have different effects as regards contamination of pressure cylinders and the lifting up and rolling round of fibers. Sizing the sticky points is therefore essential in order to correctly evaluate the impact they have.

We therefore analyzed the results given by the testing of the 42 cottons. Honeydew deposits were divided into three surface area categories, corresponding to small, medium and large. We set the limits for these categories from our experience gained with sticky cottons:

small:	from 0.9 to 5 mm^2
medium:	from 5 to 10 mm^2
large:	greater than 10 mm^2

For each repetition, table 1 shows the mean percentage by size of the 42 cottons. This percentage appears to be relatively stable. The small sticky points corresponded to 65 to 67 % of the total, the medium 14 to 15 % and the large 19 to 20 %.

Table 2 gives the size distribution of the sticky points for 4 cottons, and shows that each cotton is very different from the next. Cotton no. 4 is the least contaminated, with a mean of 10 sticky points. However, 2 of the sticky points were larger than 10 mm5. Cottons 1 and 23 are very sticky and the percentage of small sticky points in cotton 23 is very high (79.6 %), as opposed to only 63.5 % in cotton 1. Considerable size variability is therefore observed and it seems likely that these cottons will behave differently during spinning.

Conclusion

The thermodetector is used to detect cottons contaminated by insect honeydew (Brushwood and Perkins, 1993). In 1994, the machine was validated by the ITMF (International Textile Manufacturer Federation) which now recommends this technique for the measurement of stickiness caused by insects (reference 420/92).

Although the thermodetector resolved the problem caused by stickiness, it is not sufficiently rapid to give a bale by bale classification. We therefore designed another more rapid stickiness detection system (30 seconds) that is also fully automated, to give a quantitative determination of the number of sticky points and measure their size.

An excellent correlation is obtained between the results provided by the SCT thermodetector and the H2SD. A calibration method should nevertheless be developed so that all H2SD machines give consistent results.

Using these new detection methods, researchers can now obtain a continuous supply of reliable information about the stickiness problem in producer countries. They should even be able to propose solutions to decrease or even eliminate stickiness. By carefully mixing cottons, spinners will be able to reduce the incidence of stickiness, improve equipment function and enhance the quality of the yarn produced.

Acknowledgment

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Bibliography

BRUSHWOOD D.E., PERKINS H., H., Jr., 1993. Cotton stickiness potential as determined by minicard, thermodetector and chemical methods. Proceedings, Beltwide Cotton Conference, New Orleans, USA, 3, 1132-1135.

COUILLOUD R., 1986. Quelques données bilbliographiques sur les insectes producteurs de miellat. Coton et Fibres Tropicales, 41, 3, 225-228.

DAGNELIE P., 1975. Théorie et méthodes statistiques. Les Presses agronomiques de Gembloux, ASBL., vol. 1, 450 p. et vol. 2, 463 p.

DELATTRE R., 1973. Parasites et maladies en culture cotonniPre. Manuel phytosanitaire CIRAD, 146p.

FRYDRYCH R., 1986 - Détermination du potentiel de collage des cotons par thermodétection. Coton et Fibres Tropicales, 41, 3, 211-214.

FRYDRYCH R., HEQUET E., CORNUEJOLS G., 1994. A high speed instrument for stickiness measurement. 22 th International Cotton Conference of ITMF, Bremen, Germany, 83- 91.

GOZE E., 1993. Appui méthodologique aux chercheurs du projet Garoua II. Document interne CIRAD, 63 p.

HEQUET E., FRYDRYCH R., 1992. Sticky cotton from plant to yarn. Proceedings, International Committee on Cotton Testing Methods of ITMF, Bremen, Germany, appendix 46, 3-19.

HILLOCKS R. J., BRETELL J. H., 1993. The association between honeydew and growth of Cladosporium herbarum and other fungi on cotton lint. Tropic Sciences, 33, 121-129.

MARQUIE C., BOURELY J., BONVALET A., 1983. Etude chimique d'un dépôt collant sur turbines "open-end". Coton et Fibres Tropicales, 38, 4, 323-326.

PERKINS H. H.,Jr., 1971. Some observations on sticky cottons. Textile Industries, march 1971, 49-64.

PERKINS H. H., Jr., BARGERON J. D., 1980. Nep forming on a cotton card in relation to fiber maturity and cotton preparation procedures - honeydew - additives as a means to reduce air-borne dust. Proceedings of the International Committee on Cotton Testing Methods of ITMF, Bremen, Germany, 3 p.

PERKINS H. H., Jr., 1983. Identification and processing of honeydew-contaminated cottons. Textile Research Journal, august, 508-512.

PERKINS H. H., Jr., 1991. Cotton Stickiness. A major problem in modern textile processing. Proceedings, Beltwide Cotton Conference, San-Antonio, Texas, USA, 2, 523-524.

PERKINS H. H., Jr., BRUSHWOOD D. E., 1994. Cotton stickiness determined by the thermodetector method. Proceedings, Beltwide cotton Conference, San Diego, CA, USA, 3, 1412-1413.

PERKINS H. H., Jr., 1994. The thermodetector method for assessing cotton stickiness. Proceedings, International Commitee on Cotton Testings Methods of ITMF, Bremen, Germany, appendix 30, 2 p.

PERKINS H. H., Jr, BRUSHWOOD D. E., 1995. Interlaboratory evaluation of the thermodetector cotton stickiness test method. Proceedings, Beltwide Cotton Conference, San Antonio, Texas, USA, 2, 1189-1191.

SHIGEAKI IZAWA, 1992. The seriousness of cotton contamination problem as viewed from a spinner's position. Papers presented at a Technical Seminar at the 51th Plenary meeting of the ICAC, Liverpool, England, 10 p.

Table 1: Distribution of sticky points by size category (small, medium, large) for 42 cottons x 3 repetitions.

Repetitions	Mean percentage of sticky points by size category		
	Small > 0.880 to 5 mm^2	Medium > 5 to 10 mm^2	Large > 10 mm^2
Repetition 1	65.4	13.9	20.7
Repetition 2	65.6	14.4	19.8
Repetition 3	66.8	13.9	19.3

Table 2. Size distribution by category for 4 cottons

Cotton	Total number of sticky points for all 3 categories	Number of sticky points by size category		
		Small > 0.88 to 5 mm5	Medium > 5 to 10 mm5	Large > 10 mm5
Cotton 1				
rep 1	43	28	6	9
rep 2	53	37	6	10
rep 3	41	22	7	12
Mean	**46**	**29**	**6**	**10**
Percentage	**100**	**63.5**	**13.9**	**22.6**
Cotton 4				
rep 1	5	3	0	2
rep 2	11	3	4	4
rep 3	13	9	4	0
Mean	**10**	**5**	**3**	**2**
Percentage	**100**	**51.7**	**27.6**	**20.7**
Cotton 11				
rep 1	19	11	2	6
rep 2	17	11	3	3
rep 3	23	17	2	4
Mean	**20**	**13**	**2**	**4**
Percentage	**100**	**66.1**	**11.9**	**22**
Cotton 23				
rep 1	31	24	3	4
rep 2	24	19	3	2
rep 3	31	25	1	5
Mean	**29**	**23**	**2**	**4**
Percentage	**100**	**79.6**	**8.1**	**12.3**

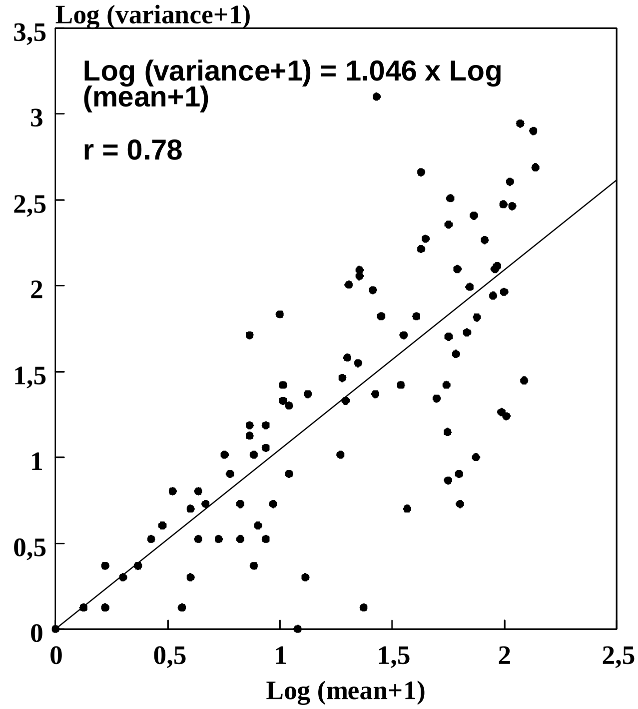

Figure 1: Mean - variance relationship for the thermodetector SCT CIRAD laboratory (96 samples)

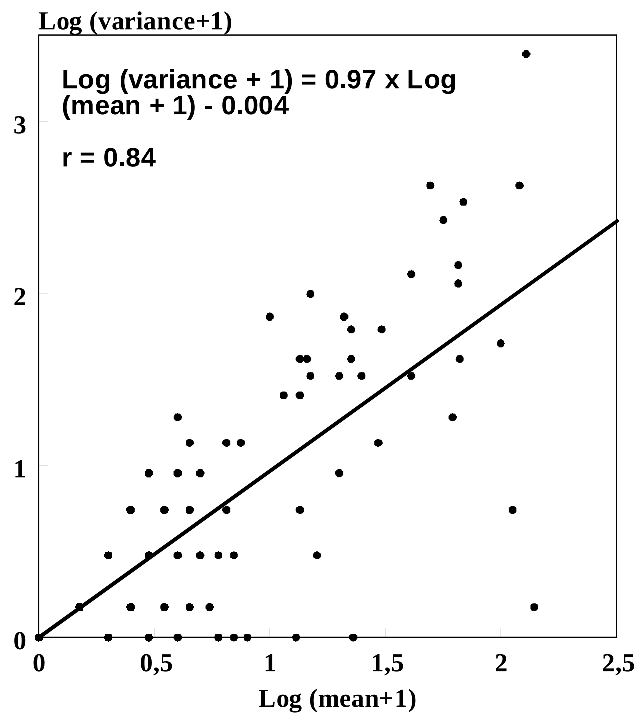

Figure 2 : Mean - variance relationship for the thermodetector SCT Cotton Incorporated laboratory (829 samples)

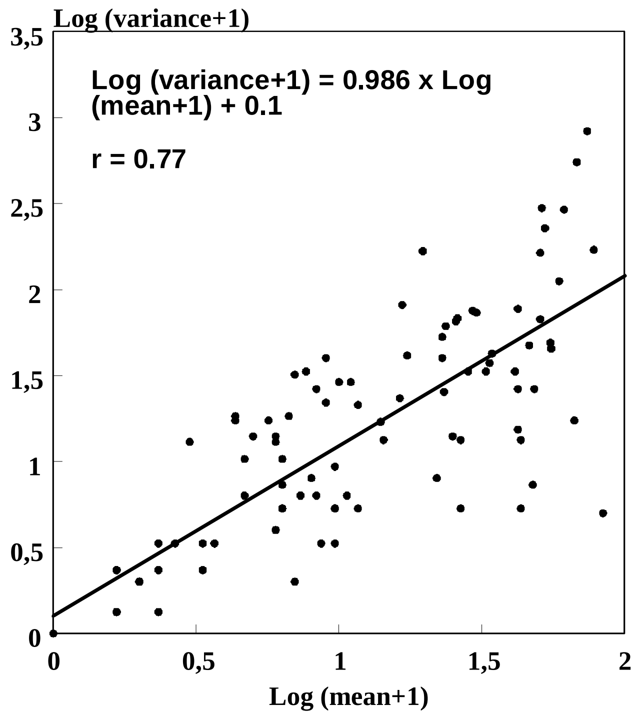

Figure 3 : Mean - variance relationship for the High Speed Stickiness Detector (H2SD). CIRAD laboratory (96 samples)

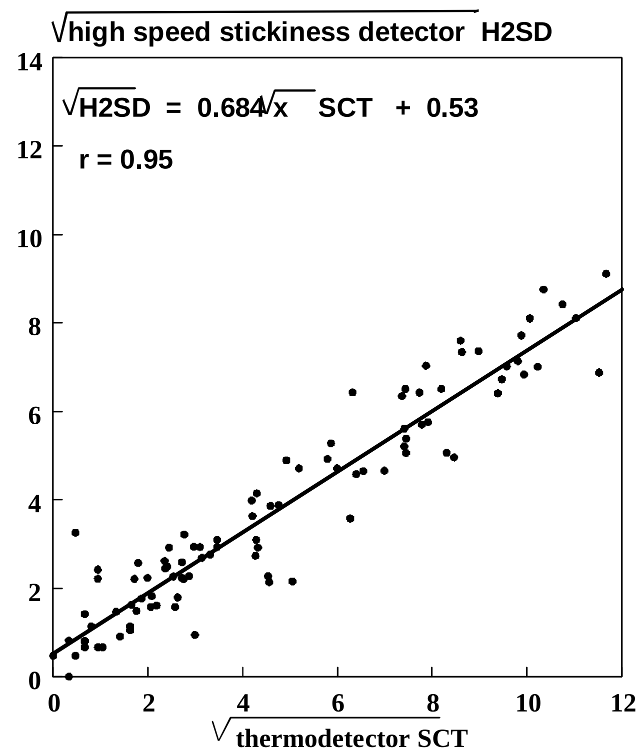

Figure 5 : Thermodetector SCT vs H2SD on 96 cottons from different countries. CIRAD laboratory

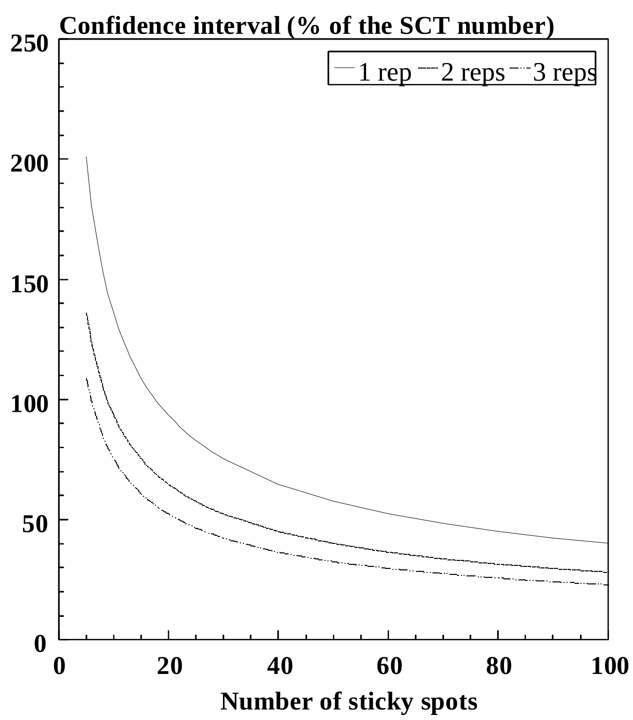

Figure 4 : Confidence intervals (%) for the number of sticky spots with SCT or H2SD

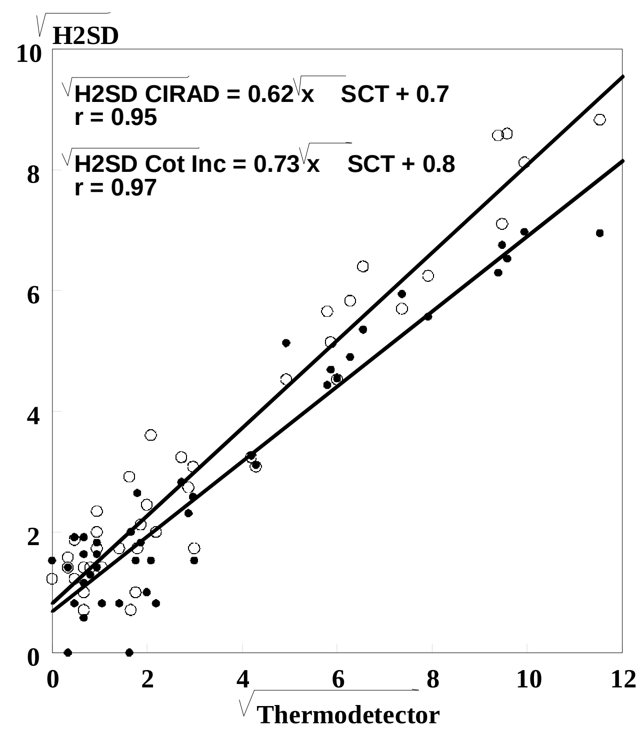

Figure 6 : SCT vs H2SD on 42 cottons from different countries. CIRAD and Cotton Incorporated laboratories

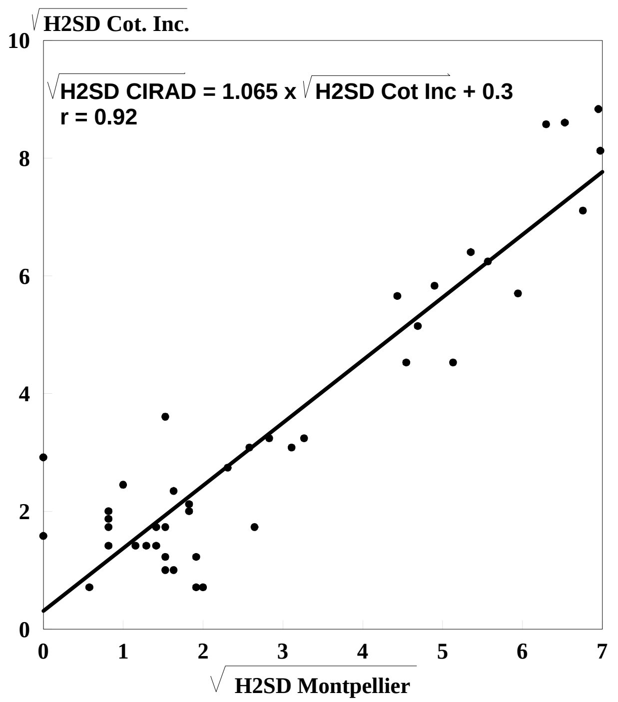

Figure 7 : H2SD CIRAD vs H2SD Cotton Incorporated on 42 cottons from different countries