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ORGANIC DUSTS

The Relationship Between Cotton Stickiness and Cotton Dust Potential

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INTERPRETIVE SUMMARY

In the early 1990's, the problem of sticky cotton became more serious than in the past. A related concern arose among researchers involving the potential accumulation of more dust on sticky cotton that would be released during subsequent processing. This might mean more frequent downtime for cleaning machinery and increased surveillance to remain in compliance with the Cotton Dust Standard. This study analyzed a large number of samples with varying degrees of stickiness. The percentage of reducing sugars, and the Sticky Cotton Thermodetector and minicard ratings for stickiness were used to determine stickiness of lint samples. These samples were also assayed for cotton dust potential, which were compared with the stickiness levels. Even though a small increased dust potential was observed when stickiness was measured by the percentage of reducing sugars and Sticky Cotton Thermodetector methods, the data indicate that stickiness and dust potential are not correlated. From a practical standpoint, increased dust levels from sticky cottons would not be expected during processing, so additional equipment or adjustments would not be needed to control dust levels.

ABSTRACT

Concerns that greater cotton dust potential may be associated with increased cotton stickiness prompted a survey to determine if this would be a potential problem in the processing of sticky cotton. A large collection of cottons with varying levels of stickiness was assayed for cotton dust potential and compared. The results suggest a small increase of cotton dust potential is associated with stickiness when using the percentage of reducing sugars and Sticky Cotton Thermodetector stickiness ratings; however, stickiness was not correlated with the level of dust, and level of dust was not increased with greater minicard stickiness ratings. This suggested that stickiness did not influence the level of dust potential, and from a practical viewpoint, no additional adjustments to control cotton dust are necessary during the processing of sticky cottons.

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The industrial concern about stickiness during the early 1990's posed the question, "Is there any relationship between stickiness and cotton dust?" This concern arose because of the possibility that increased occurrence of stickiness might also be accompanied by increased levels of cotton dust being released during processing. Perkins (1971) described the practical problems of stickiness, which were further elaborated on by Hequet and Frydrych (1992). Later, even more detailed investigations on the nature of stickiness in cotton (Brushwood and Perkins, 1994; Hendrix et al., 1993; Roberts et al., 1976), and possible remedies (Balasubramanya et al., 1985; Carter, 1990; Chun and Brushwood, 1998; Heuer and Plaut, 1985; Perkins, 1993) were conducted. A large amount of information is available on stickiness and cotton dust separately, but less work has been done on cotton dust and stickiness together. Reasonable rationalizations could be made for both lower and higher cotton dust potential with sticky cottons. A study by Chun et al. (1995) gave the first indication that sticky cotton may have greater cotton dust potential, and suggested that sticky cottons may 'trap' and accumulate more airborne dust or soil, or that the sticky material itself may be released as dust. In that study, the number of samples was small, the contrast between the non-sticky and the sticky cotton was extreme, the cotton was from a localized region and grown for research studies under conditions that would foster whitefly honeydew stickiness. This study was initiated in response to this early finding and to compensate for the weakness of this first work by: 1) expanding on the sample size, 2) collecting samples from a wider range of the Cotton Belt, including California, 3) using samples from the entire range of stickiness; and 4) including minicard stickiness measurements, which is the favored method of measuring stickiness at the Cotton Quality Research Station.

MATERIALS AND METHODS

Cotton Samples

Cottons samples sent to the Cotton Quality Research Station from around the country, representing major domestic growing areas, were collected and assayed for the percentage of reducing sugars, and stickiness level using the Sticky Cotton Thermodetector and minicard, and then sub-sampled for cotton dust potential. The cotton samples consisted of cotton collected from ongoing studies at the Cotton Quality Research Station, where Sticky Cotton Thermodetector, sugar or minicard data are available for samples acquired from 1999 through 2001. Additional samples were taken from cotton sent to the Cotton Quality Research Station for service tests. These samples came from all regions of the Cotton Belt, including California. The sources of the cottons sent to the Cotton Quality Research Station for service tests were kept anonymous for this study. Thousands of cotton samples are sent to this location for fiber quality testing. Since these samples are analyzed for different properties, preference was given to samples where the percentage of reducing sugars, Sticky Cotton Thermodetector, or minicard data were already performed to reduce the number of tests done. When only partial data were available, the missing assay was performed so that for each sample, the percentage of reducing sugars, Sticky Cotton Thermodetector stickiness and minicard stickiness data were available. Samples were selected in regard to their level of stickiness based on Sticky Cotton Thermodetector and minicard stickiness ratings, so that there would be representative samples for each stickiness category. A sample size estimate was not performed, but from previous experiences, the 400 cotton samples assayed for this study was believed to be more than adequate.

Percentage of Reducing Sugar

Total reducing sugars, including glucose, fructose and trehalulose, were determined using the routine potassium ferricyanide test (Perkins, 1971, 1993a), also called the USDA potassium ferricyanide or Perkins test, and the percentage of reducing sugars was based on dry weight of the sample. For this test, a single 1-gm lint sample was used for each determination. The percentage of reducing sugar test measures reducing sugars and does not directly measure stickiness; but when levels of reducing sugars reach 0.35% or higher, the potential problem of stickiness in processing exists (Perkins, 1993a). So indirectly, the percentage of reducing sugar test is used as an indicator of stickiness; and has only two categories of stickiness, non-sticky and sticky cottons.

Sticky Cotton Thermodetector Stickiness

Cotton stickiness potential was determined using the GRAF/IRCT Sticky Cotton Thermodetector (GRAF, Montpellier, France) (Brushwood & Perkins, 1993 & 1993a; Perkins & Brushwood, 1994, 1995). For this test, a single 2½-gm lint sample was used for each determination. The tests were performed at 55 to 65% relative humidity, with a target relative humidity of 60% ± 2% at 22° ± 2° C. In this test, a web of cotton is heated between sheets of aluminum foil after which sticky spots left on the foil are counted. The Sticky Cotton Thermodetector is being used as an alternative to the less available minicard for determining stickiness because of the smaller initial investment, cost, mobility and reliability. Comparison tests have shown coefficients of simple correlations of 0.89 and 0.97, so minicard results are highly correlated with Sticky Cotton Thermodetector results (Brushwood & Perkins, 1993 & 1993a; Perkins & Brushwood, 1994, 1995). The four categories of stickiness, which were originally referenced to the minicard stickiness ratings, were determined based on the number of Thermodetector spots from the assay: (a) nonsticky, less than 5, (b) light stickiness, 5-14, (c) moderate stickiness, 15-24 and (d) heavy stickiness, above 24 spots.

Minicard Stickiness

The Sticky Cotton Thermodetector was identified as a recommended testing method in 1994 largely because the minicard is not available on the open market to implement testing (Anonymous, 2000). Since the minicard is the backbone reference for stickiness that most closely mimics the problem of stickiness in the industry and had been adopted as the reference method for assessing cotton stickiness by the International Committee on Cotton Testing Methods of the International Textile

Manufacturers Federation (ITMF) (Anonymous, 1988), minicard stickiness measurements were also taken. Cotton stickiness potential was determined using the standard minicard (Shirley Spinning System, Lancashire, England) and its rating system (Brushwood & Perkins, 1993 & 1993a).

For this test, a single 10-gm lint sample was used for each determination. The tests were performed at 55 to 65% relative humidity, with a target relative humidity of 60% ± 2% at 22°± 2°C. The four rating levels are: 0 (no stickiness), 1 (light stickiness), 2 (moderate stickiness), and 3 (heavy stickiness). The rating levels are based on five factors: (1) the number of times stickiness occurs on the delivery rolls; (2) the size of the sticky masses; (3) the tendency for the fiber web to wrap around the rolls; (4) the time for stickiness to develop on the rolls; and (5) the amount of residual sticky masses remaining on the delivery rolls after the test. The number of times stickiness occurs, the size of the sticky masses and amount of residual sticky masses, are subjective observations made by an experienced operator.

Cotton Dust Potential

A Microdust and Trash Monitor (MTM; Schoffner Technologies, Knoxville, TN) was used to determine cotton dust potential (Millner et al., 1988; Sasser et al., 1986) as described by Chun and Perkins (1996). The cotton dust potential assay was done by the Testing Laboratory at Cotton Quality Research Station. A 20-gm portion of lint was assayed for each sample. The results are reported as the total cotton dust per 20-gm sample.

Statistical Analysis

Comparisons of the means of the cotton dust potential associated with the various categories of stickiness were used to understand the relationship between stickiness and cotton dust potential. Data were analyzed on a personnel computer using release 8.00 of SAS for Windows (SAS Institute Inc., Cary, NC) for making mean comparisons if significant F-tests resulted from analysis of variance tests. Otherwise additional testing and data manipulation such as chi-square test, regression analysis, t-tests analysis and plotting, were done with Microsoft EXCEL 2000 for Windows (Microsoft Corporation, Redmond, WA) and SigmaPlot 2001 for Windows (SPSS, Inc., Chicago. IL).

RESULTS AND DISCUSSION

The relationships between cotton dust potential and stickiness using the percentage of reducing sugars, Sticky Cotton Thermodetector and minicard stickiness, are portrayed in Figures 1 to 3. The percentage of reducing sugars, which categorizes cotton either as potentially non-sticky or as potentially sticky cottons, showed the greatest correlation with cotton dust potential (Figure 1). The difference between the mean dust potential of sticky and non-sticky cottons was significantly different from zero ($t = 3.779$, d.f. = 245, $P < 0.001$), which suggests that sticky cottons had a greater cotton dust potential based on the percentage of reducing sugar stickiness, but this difference was very small, 0.241 mg 20-g^{-1}. The mean for the non-sticky cottons was 1.944 mg 20-g^{-1} (n=119) and for the sticky cottons 2.186 mg 20-g^{-1} (n=281). The correlation coefficient for percentage of reducing sugar and cotton dust potential was 0.355. Even when the non-sticky and sticky portions were plotted separately, the correlation was poor ($r = 0.077$ and 0.358, respectively).

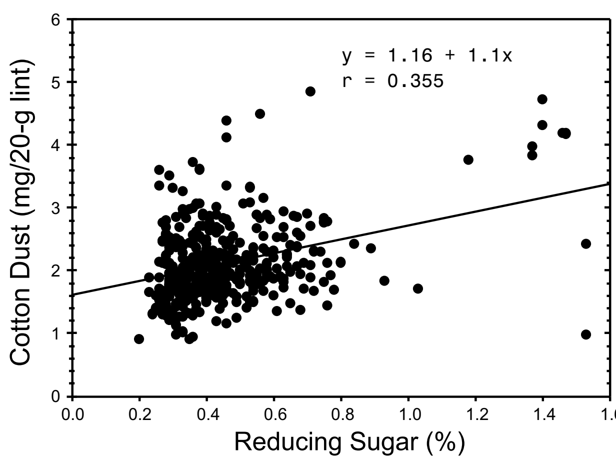

Figure 1. Scatter plot and simple linear regression line of the percentage of reducing sugar stickiness and cotton dust potential. Non-sticky cottons have < 0.35% sugar and sticky cottons have > 0.35% sugar.

There was poor correlation between Sticky Cotton Thermodetector stickiness and dust potential (Figure 2). But when cotton dust potential was sorted by stickiness rating, sticky cottons tended to have greater cotton dust potential than non-sticky cottons (Table 1). The difference between non-sticky cotton and the sticky category with the highest dust potential was small. The mean for non-sticky cotton was just 1.957 mg 20-g^{-1} and moderately sticky cotton was 2.267 mg 20-g^{-1}. Non-sticky cotton was

Table 1. Cotton dust potential of cottons at different sticky cotton thermodector ratings

Thermodetector Rating (number of spots)	No. of Samples	Average Dust (mg 20-g^{-1})
Non-sticky, less than 5	72	1.957 b[x]
Light stickiness, 5-14	126	2.170 a
Moderate stickiness, 15-24	61	2.267 a
Heavy stickiness, greater than 24	141	2.077 ab

[x] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test (*P*≤0.05).

Table 2. Cotton dust potential of cottons at different minicard ratings

Thermodetector Rating (number of spots)	No. of Samples	Average Dust (mg 20-g^{-1})
Non-sticky, less than 5	81	2.116 ab[x]
Light stickiness, 5-14	89	1.946 b
Moderate stickiness, 15-24	659	2.171 a
Heavy stickiness, greater than 24	171	2.180 a

[x] Means within a column followed by the same letter are not significantly different according to Duncan's multiple range test (*P*≤0.05).

significantly different from the light and moderately sticky cottons but was not significantly different from the heavy sticky cotton. Most of the high dust potential observations fell within the non-sticky to moderately sticky range (0 to 24 spots); but this correlation (r = 0.358) was poor.

Significantly different levels of cotton dust potential were found between the different minicard ratings (Table 2), but sticky cottons do not appear to have a significantly greater cotton dust potential than non-sticky cottons. Moderately and heavily sticky cottons tended to have greater cotton dust potentials than lightly-sticky and non-sticky cottons (Table 2); nevertheless, the differences were very small. The mean dust potential was 1.946 mg 20-g^{-1} for slightly sticky cottons to 2.18 mg 20-g^{-1} for heavily sticky cottons and neither had significantly higher dust potential than non-sticky cotton, 2.12 mg 20-g^{-1}. This was also observed when dust potential was plotted against the minicard ratings for stickiness (Figure 3). The minicard rating system uses 0, 1, 2 and 3 as categories of stickiness, but these rating steps behave linearly in regard to stickiness (Brushwood & Perkins, 1993 & 1993a; JD Bargeron, personal communication, 2002) so a simple regression of dust and stickiness was conducted (Figure 3). The correlation coefficient (r = 0.09) between dust and stickiness was very poor. This is further supported by a two-way classification test using chi-square analysis of the different ranges of dust potential and minicard stickiness. The chi-square was not significant (χ^2 = 21.66, d.f. = 16, P = 0.25), so

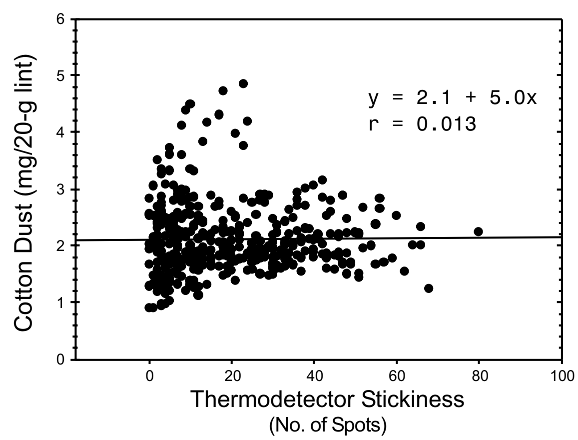

Figure 2. Scatter plot and simple linear regression line of the Sticky Cotton Thermodetector stickiness and cotton dust potential.

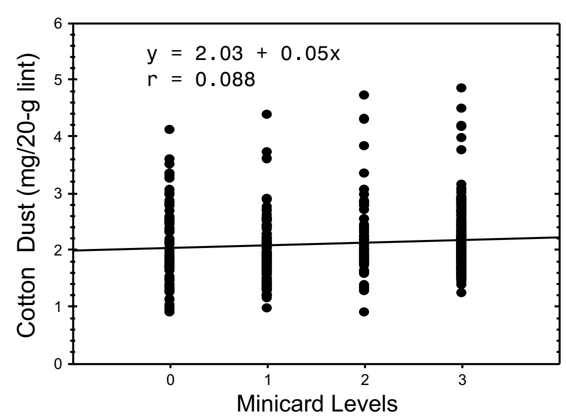

Figure 3. Scatter plot and simple linear regression line of the minicard stickiness and cotton dust potential. The four increasing categories of stickiness are: 0=no stickiness, 1=light stickiness, 2=moderate stickiness, and 3=heavy stickiness.

there was no reason to associate unusual levels of dust with specific categories of minicard stickiness.

As shown when using the percentage of reducing sugar and Sticky Cotton Thermodetector for measuring stickiness, significantly higher levels of dust potential can be associated with sticky cottons. A practical interpretation however, is that stickiness is poorly correlated with cotton dust potential as shown by the low correlation coefficients. From the standpoint of the cotton industry, the smallness of these differences becomes clearer when the average dust potential was plotted against stickiness (Figures 4 to 6). Such small differences would be inconsequential during the normal processing of cottons, especially in regard to the Cotton Industry remaining in compliance with the Cotton Dust Standard.

Even though Sticky Cotton Thermodetector and reducing sugar stickiness indicate greater dust potential associated with stickiness, most of the evidence points to a lack of association between stickiness and dust potential, especially when the minicard results indicate a lack of association between stickiness and dust potential. These results are in stark contrast to the early pilot study done by Chun et al. (1995) that showed sticky cotton had a 2.4 times greater cotton dust potential than its non-sticky counterpart. Very likely this finding was peculiar to this study. In this work, the cottons were grown in experimental plots in Brawly, CA, specifically for stickiness studies. These cottons were artificially infested with dense populations of whiteflies so that the amount of honeydew contamination limited the commercial usefulness of the lint without special handling. These cottons were non-sticky and heavily-sticky cottons (1.17% reducing sugar and 36 Sticky Cotton Thermodetector spots) and represented the extremes of stickiness. As suggested by Chun et al. (1995), sticky cottons may ‘trap’ and accumulate more airborne dust or soil, or the sticky material itself may be released as dust. But this effect of stickiness would probably only be effective in the sticky spotted areas of the lint. Chun et al. (1995) only compared two categories of cotton, a non-sticky and an artificially created set of sticky cottons. The sticky cotton had 4.68 times more reducing sugars and had 18 times more sticky spots than the non-sticky cotton used for comparison, which may partially account for the association of dust with stickiness. Also, minicard assessment of stickiness was not addressed in associating stickiness and dust potential. The study in 1995 was a

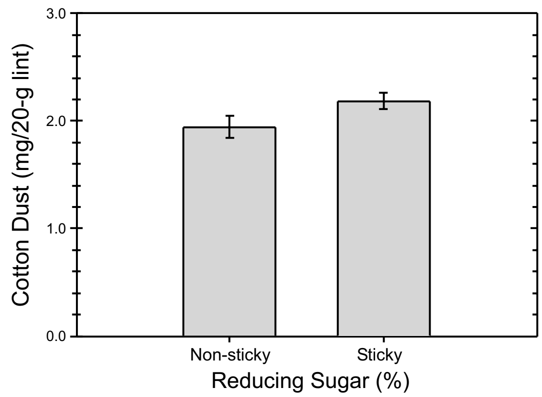

Figure 4. Cotton dust potential associated with different percentages of reducing sugar stickiness. Non-sticky cottons have < 0.35% sugar and sticky cottons > 0.35% sugar. Each half bar represents 2 s.e.

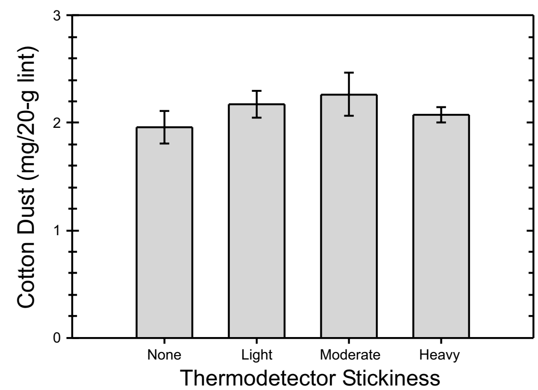

Figure 5. Cotton dust potential associated with Sticky Cotton Thermodetector stickiness ratings. The four categories of stickiness, which were originally referenced to the minicard stickiness, were determined based on the number of Thermodetector spots from the assay: (a) Nonsticky, less than 5, (b) Light Stickiness, 5-14, (c) Moderate Stickiness, 15-24 and (d) Heavy Stickiness, above 24 spots. Each half bar represents 2 s.e.

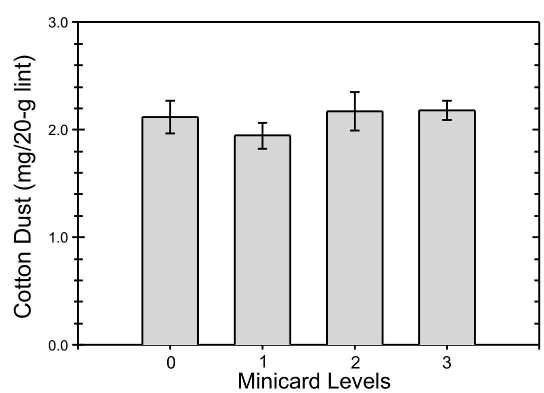

Figure 6. Cotton dust potential associated with the minicard stickiness categories. The four increasing categories of stickiness are: 0= no stickiness, 1=light stickiness, 2=moderate stickiness, and 3=heavy stickiness. Each half bar represents 2 s.e.

small preliminary study into the relation between stickiness and dust potential to see if any differences could be found and was later expanded to the current study, which used more typical samples. Stickiness levels as found in Chun et al. (1995) were represented in this study (Figures 1 and 2); and this study included a very large number of samples from the commercial growing regions of the Cotton Belt, including California, as well as the categories of stickiness. Since minicard stickiness ratings are the best mimic of stickiness during processing, the results indicate that from a practical perspective, cotton stickiness is not correlated with increased or decreased cotton dust potential. Very likely the lack of correlation, between stickiness and dust potential as found in this study, is a truer representation of what is observed by the Cotton Industry.

DISCLAIMER

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