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Sticky Cotton Sources & Solutions

SUMMARY

From field to textile mill, all stages of the cotton industry are adversely affected by sticky cotton. Honeydew deposited by phloem-feeding insects such as whiteflies and aphids, and sugars produced by the plant itself may build up to levels that impede fiber handling. Typically, stickiness is first encountered when sugar-contaminated cotton lint is carded at the textile mill. Growers often sustain considerable costs in managing honeydew-producing insects. Further, if stickiness is found by textile processors, growers in regions associated with sticky cotton may suffer price reductions in future years. At present, no test for sugars contamination is as rapid as HVI testing. Moreover, no current test of sugars contamination has been directly calibrated with fiber processing efficiency. Because current measures for mitigating stickiness in the field and at the mill are unreliable, stickiness is best avoided by managing insect and plant sources. Well-implemented integrated pest and plant management plans are our best defenses against the stickiness problem. Having put such plans to work, cotton growers in the western United States have minimized the risks of sticky cotton.

What is Stickiness?

To growers, stickiness means higher costs for insect control and reduced cotton marketability. To ginners, stickiness may mean special handling and processing requirements. At the textile mill, stickiness means reduced processing efficiency, lower yarn quality, and in severe cases total shut down. For everyone concerned, stickiness means reduced profitability. Stickiness occurs when excessive sugars present on fibers are transferred to equipment and interfere with processing. Sugars may be insect- or plant-derived. Though sugars are ubiquitous in lint, they usually occur at levels that pose no processing difficulties. This bulletin details the sources and components of problem sugars on harvested lint, the processing and marketing impacts of stickiness, and strategies for avoiding or mitigating stickiness.

Honeydew, when present in sufficient quantity, is the main source of sugars that can result in sticky lint. Honeydew is excreted by certain phloem-feeding insects including such common pests of cotton as aphids and whiteflies. These insects are capable of transforming ingested sucrose into over twenty different sugars in their excreted honeydew. The major sugars in cotton insect honeydew are trehalulose, melezitose, sucrose, fructose and glucose.

Another source of stickiness is free plant sugars sometimes found in immature fibers. Cotton fiber is largely cellulose that is formed from sugars synthesized by the plant. Dry, mature cotton fibers contain little free sugar, while immature cotton fibers contain glucose, fructose, sucrose, and other sugars. If immature cotton fiber is subjected to a freeze, complex sugars may be broken down to release additional simple sugars. Less commonly, oils released by crushed seed coat fragments can also result in stickiness. In this case, raffinose is the characteristic sugar.

Sugars differ in their stickiness. For example, sucrose, melezitose, and trehalulose are all significantly stickier when deposited on fiber than are glucose or fructose. Further, trehalulose-contaminated fiber is stickier than fiber with an equivalent amount of melezitose. Mixtures of sugars, such as occur in honeydew, tend to be stickier than single sugars. Localized concentration of sugars like honeydew is at higher risk of causing stickiness than more evenly distributed sources like plant sugars.

Impact of Stickiness on Growers & the Marketplace

Between insect control costs and reduced cotton prices, sticky cotton is costly to growers. The major cost is in controlling the potential sources of stickiness. The costs of aphid control in TX and CA, and of whitefly control in TX, AZ and CA have all increased in the last decade. Insecticide treatment to specifically prevent stickiness has cost Southwestern cotton growers $47 million for aphids and $154 million for whiteflies from 1994–98 (Table 1). In AZ, the cost of controlling whiteflies increased from $12/acre in 1990 (the onset of the whitefly outbreak) to $145/acre in 1995. This cost accounted for 11% in 1990 and 68% in 1995 of the total spent on insect control. A new integrated system of whitefly management based on insect growth regulators began in 1996. Since then, AZ growers have reduced control costs to less than $35/A, while achieving excellent whitefly control. The 1996 AZ crop was found to be 98% free of stickiness as determined by random bale testing with SCT (see next section). In


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The specter of 'sticky' cotton has affected large regions of the world's production. Better plant and insect management are keys to avoiding this costly problem.

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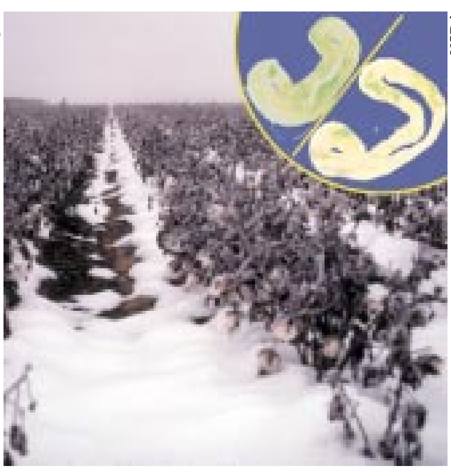
The cotton aphid, Aphis gossypii*, excretes honeydew rich in melezitose (ca. 30–40%). Their droplets (inset, 50X) tend to be larger than those produced by whiteflies.*

1997, CA cotton growers spent a statewide average of $7/A on whitefly control and $38/A on aphid control. Combined, these costs accounted for over half of their total insect control budget. In TX, aphid and plant sugars have been the largest sources of stickiness. TX cotton growers have spent up to $19/A (1995) on aphid control and $21/A (1991) on whitefly control. In addition to these immediate costs, excessive dependence on chemical control tactics carries with it increased frequency and risks of insecticide resistance with an incalculable cost to growers and the industry.

Sticky cotton can reduce cotton gin output (in bales/hr) by up to 25%. At the textile mill, excessive wear and increased maintenance of machinery may occur even with slightly sticky cotton. In severe instances mill shutdown with a thorough cleanup is required.



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A preharvest freeze can set off a chain of events that leads to immature fibers and excessive plant sugars. Inset (250X) are cross sections of fibers, normal (left) & immature (right). Note wall thicknesses and lumen volume.

A reputation for stickiness has a negative impact on domestic sales, export orders, and prices for cotton from regions suspected of stickiness. The precise loss of sales due to stickiness is difficult to estimate, because cotton consumption and exports are affected by many factors every year. Cotton price is reduced for stickiness by the market at a rate proportional to the perception of risk. Reductions in the market value of lint are applied regionally and indiscriminately. Regional penalties are a consequence of the difficulty in measuring stickiness in cotton. Because there is currently no rapid method that is accepted as an industry standard for the measurement of stickiness, there can be no formal, bale-specific schedule of discounts for stickiness in the USDA-AMS cotton classification system. Estimates of the immediate effects of stickiness on regional cotton prices are reductions up to $0.03–0.05 / lb for AZ since the whitefly outbreak of 1992 (Fig. 1), and at least $0.03 / lb for West TX in 1995. Since 1992, growers in AZ may have lost as much as $21 million (1993–1995) and $36 million (1996–1998). In West TX, prices were affected primarily for the 1995 crop. A similar market penalty could be re-imposed in any region should the potential for stickiness be suspected.

In addition to causing price reductions for cotton lint, estimates of losses due to whitefly feeding in southwestern agricultural communities exceeded $200 million in 1991 and $500 million in 1992. In the Imperial Valley, CA alone, annual crop losses to the silverleaf whitefly from 1991 to 1995 have been estimated to be about $100 million. In 1992 and 1995, whitefly feeding directly reduced cotton yields in AZ, as did aphid feeding during the mid-season of 1995 and 1997 in CA.

Stickiness Detection & Measurement

'Stickiness' is the physical process of contaminated lint adhering to equipment (Fig. 2). The degree of stickiness depends on the chemical identity, quantity, and distribution of the sugars, the ambient conditions during processing—especially humidity—and the machinery itself. Stickiness is therefore difficult to measure. Nonetheless, methods for measuring sugars on fiber have been and are being developed. These measurements may be correlated with sticking of contaminated lint to moving machine parts. Currently, no generally recognized system of stickiness measurement is compatible with the speed of commercial cotton classing. The physical and chemical attributes of the lint and sugars that are correlated with stickiness have been measured in many ways, each with differing efficiency and precision.

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Whiteflies, Bemisia *spp., also excrete honeydew, but as trehalulose-rich (ca. 40–50%) droplets (inset, 50X).*

Some textile mills use reducing-sugar tests based on reduction of the cupric ion to screen for sugar contamination. These tests are relatively quick and inexpensive. However, some insect sugars are not reducing sugars, and some others are measured at different levels of efficiency by various reducing-sugar methods. Thus conventional reducing-sugar tests are best reserved for screening lint that potentially has high levels of plant sugars. In these cases and with the potassium ferricyanide (KFeCN) test, lint with reducing sugar levels below 0.3% may be processed without difficulty.

High Performance Liquid Chromatography (HPLC) identifies and measures both reducing and nonreducing sugars. The main sugars of insect honeydew, trehalulose (from whiteflies) and melezitose (from aphids), and of plant sugars (glucose, fructose & sucrose) are all readily identified in this test. The benefit of HPLC analysis is the identification of the source of contamination (whitefly, aphid, or plant) which may help identify specific mitigation measures.

The physical interaction of all sugars on lint with equipment can be measured by several types of machines. The primary difficulty with these physical tests is in standardizing the stickiness measurement. As with chemical testing, these tests must be correlated with measures of fiber processing efficiency in order to interpret the results.

One of these tests, the minicard, is a physical test that measures actual cotton stickiness of the card web passing between stainless steel delivery rollers of a miniature carding machine. Modeled after a production carding machine, the minicard must be run under strict tolerances. A '0' minicard rating indicates that no sticking was observed, while progressively higher numbers (on a 0–3 scale) indicate progressively greater amounts of sticking during the process. Cottons with high plant sugar contents evenly distributed along the fibers may fail to be measured as sticky in this test. The minicard test is slow and has been replaced as the international standard by the manual thermodetector (see next section).

The Sticky Cotton Thermodetector (SCT) measures the physical sticking points transferred to aluminum sheets by a conditioned lint sample that is squeezed and heated (to 82.5°C for 12 sec.). Levels of stickiness are categorized according to the number of specks left on the two sheets of foil. Lower numbers of specks are preferable to higher numbers; however, a specific threshold over which all cotton will result in processing problems has not been defined. The SCT takes about 5 minutes to process each sample, requires smaller initial investment costs than the minicard, is more mobile, and its results correlate well with predicted stickiness from the minicard.

The High Speed Stickiness Detector (H2SD) is a quicker, automatic version of the thermodetector. The cotton sample is pressed between a heated (54°C for 30 sec.) and an unheated pressure plate. Sticky points are counted and point size distribution determined by image-processing computer software. Plates are automatically cleaned between samples. The H2SD is able to analyze a sample in 30 seconds.

Like the thermodetector and H2SD, the Fiber Contamination Tester (FCT) measures physical sticking points (at 65% RH). The instrument feeds a thin web between two rollers. Contamination of the rollers interrupts a laser beam, resulting in a recording. Because the cleaning and recording is automated, samples may be processed as quickly as one per 45 seconds.

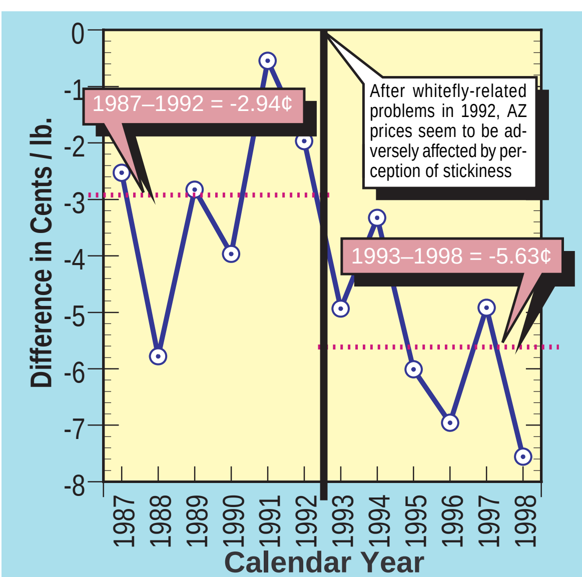

Figure 1. *Average† weekly spot price difference of Arizona (DSW) minus California (SJV) upland (31-3/35). Market forces other than stickiness may also be acting on these differences.*

† Source: USDA-AMS, Cotton Price Statistics, 1987–1998.

While there is no reliable in-field method for detection of stickiness predisposition, the insects responsible for honeydew deposits can be sampled and populations measured. Not all population levels of insects lead to sticky lint; however, chronic numbers of insects, especially during boll opening or an extended season, can lead to excessive insect sugars that result in stickiness. In addition, field factors associated with risk of excessive plant sugars are lateness of the crop, fiber immaturity, and freezing temperatures before harvest.

Table 1. **Costs (in $US millions) of aphid and whitefly control in Arizona, California and Texas, 1994–1998 (for yield protection & stickiness prevention).**

APHID						
State	1994	1995	1996	1997	1998	Sum
AZ	0.0	0.7	0.1	0.0	0.4	1.2
CA	33.4	25.5	4.8	40.3	2.3	106.3
TX	11.3	23.0	8.1	9.9	5.5	57.8
Sum	44.7	49.2	13.0	50.2	8.2	165.3
WHITEFLY						
AZ	27.5	58.1	18.7	17.3	8.9	130.5
CA	0.0	1.7	3.0	7.9	1.1	13.7
TX	0.0	9.5	0.0	0.0	0.2	9.7
Sum	27.5	69.3	21.7	25.2	10.2	153.9

Work is currently underway to determine methods for measuring insect sugars on field-collected lint as a tool for predicting stickiness. Such predictions would be complicated by various degradative processes that occur prior to processing such as rain and microbial activity that might reduce the potential for stickiness.

Managing the Sources

The most efficient way now to prevent stickiness is by managing sugar sources in the field. Detailed integrated pest management plans (see references) for both aphid and whitefly have been developed in AZ, CA, and TX. These honeydew-producing insects may be managed by avoiding conditions leading to outbreaks, carefully sampling pest populations, and using effective insecticides when populations reach predetermined thresholds.

The risk of having excessive plant sugars can be minimized by harvesting mature seed cotton. This may be accomplished through plant management tactics that include: early and uniform planting, nitrogen management according to plant growth and yield goals, high first-position boll retention, and timely chemical termination and harvest. If a freeze is imminent and immature bolls are present, the use of boll-opening chemicals can greatly diminish the problem of plant sugar contamination. All these measures work towards early harvest, before freezing conditions that contribute to excess plant sugars.

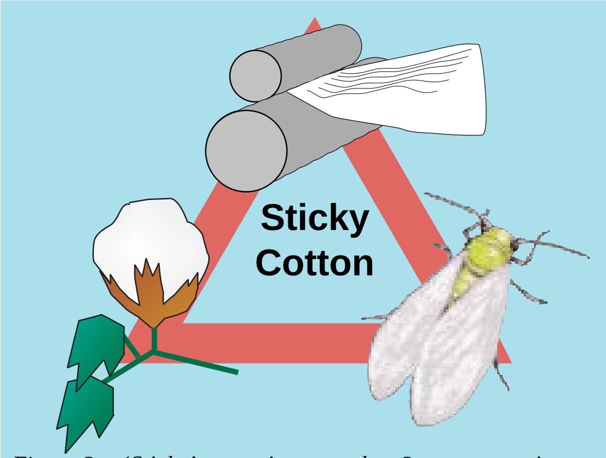

Figure 2. *'Sticky' cotton is a complex, 3-component interaction among source (insect or plant sugars), lint, and processing equipment.*

Mitigating the Problem

When field management of sugar sources is inadequate to prevent excess accumulation of sugars, mitigation tactics may be necessary to remove excess sugars from the lint. This mitigation may be achieved through both natural and managed processes; however, the specific impact of these processes on stickiness is variable and may depend on the initial level of contamination. Natural processes include weathering, rainfall, and degradation by microorganisms. Since sugars are water soluble, rainfall will wash some honeydew from lint. If sufficient moisture is available, bacteria and molds living on the plants will decompose many honeydew sugars. Complex sugars are broken down to simpler sugars, and the simpler sugars, given sufficient time and moisture, are further broken down to carbon dioxide and water. Unfortunately, microbial action also leads to discoloration and to a weakening of the fibers as well as heating of cotton in modules that may result in reduced seed viability and problems in ginning.

Potential in-field mitigation techniques include supplemental oversprays of enzymes or water. Certain carbohydrate degrading enzymes when sprayed on sticky cotton can reduce honeydew to simpler sugars. Microbial activity on the fibers then further degrades these simpler sugars, resulting in a significant decrease in fiber stickiness. However, these enzymes require water for activity, and metering the proper amount of water for activity is a problem yet to be solved. In some areas of the world, overhead and in-canopy irrigation has been used to remove honeydew from open bolls. The frequency of this type of irrigation may be more important than the volume applied. Use of sprinklers has been limited in the Western United States, where furrow irrigation is prevalent.

If stickiness is a problem while ginning, the ginning rate of honeydew contaminated cotton can be increased by increasing the heat of the drying towers to reduce humidity. The potential for stickiness can be further reduced by lint cleaning. Both of these practices, however, can result in shorter fibers. Conventional textile lubricants may also be used. Stickiness due to high levels of plant sugars can be reduced by storing the cotton for approximately six months. However, storage of baled cotton will not appreciably reduce stickiness from insect sugars. At the textile mill, stickiness may be managed by blending bales and by reducing humidity during carding. A lubricant in fog form may be introduced at the end of the hopper conveyor, and card-crush rolls may be sprayed sparingly with a lubricant to minimize sticking.

Conclusion

Lints contaminated with sugars from various sources (plant and insect) can result in stickiness. Yet stickiness is not an intrinsic property of the lint and therefore cannot be measured directly. Rather, stickiness is a complex, three-component interaction that involves the source sugars, harvested seedcotton, and processing equipment. The complexity of this interaction indicates the need for an integrated solution that includes prevention, in-field mitigation, and processing adjustments. Because currently our best means of eliminating stickiness is source sugar minimization in the field, US agricultural research and implementation agencies continue to emphasize successful insect and crop management plans.

Endorsing Organizations

The University of Arizona, The University of California, Texas A&M University, United States Department of Agriculture, Cotton Incorporated, National Cotton Council

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For more information about cotton stickiness and insect/crop management, including this publication, visit the internet site: **ag.arizona.edu/cotton**.

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