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Causes of High and Low Micronaire

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1990 U.S. Cotton Crop

As the 1990 cotton harvest season gears up, it appears that much of this crop may have problems with high micronaire. The Texas, Louisiana, Arizona, South Carolina and Arkansas crops are all averaging 44 or higher mike during the early classing period. Most producers have not been concerned with out-of-range mike because of the wide (3.5 to 4.9) base range for mike in the marketing system. However, beginning next year a new premium and discount system is scheduled to be put in place that will provide producers with an opportunity for increased income through careful selection of varieties and management practices.

Micronaire Premiums and Penalties

Both high and low mike cotton are limited in range of use by the textile industry. Low mike cotton can be fine fiber but usually is immature fiber that does not readily absorb dye and thus creates an uneven dye pattern in the finished cloth. Low mike cotton is also more likely to form neps (small knots of tangled fiber) in the ginning and yarn manufacturing processes. Neps are detrimental because they cause ends down (yarn breakage) in the spinning process and white specks (non-dyed spots) in dyed fabrics. This problem is more likely in low mike cotton, although high mike cotton can also produce white specks.

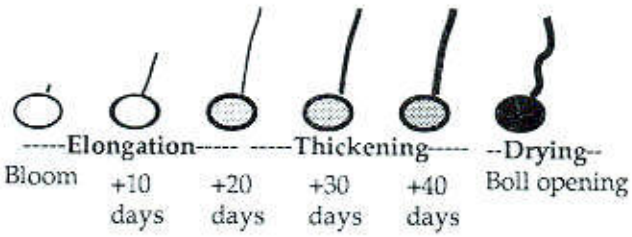
High mike cotton also has limited use by the textile industry because it cannot be spun efficiently into fine yarns. A minimum of 100 cotton fibers per cross section of yarn are required in the spinning process to hold yarn together and give it strength. If coarse, high mike cotton is used, these 100 fibers can only make a coarse, thick yarn. Coarse yarns are used to make denim, polyester blends and non-wovens such as batting, in which fineness is not critical. Thus coarse fiber rarely receives a premium in the marketplace even if extra strong or extra long.

One of the recommendations of the USDA Advisory Committee on Cotton Marketing establishes a premium range for micronaire from 37 to 42, beginning with the loan schedule in 1991. The base range will now be in two segments 35 to 36 and 43 to 49. Bales with mike readings in these ranges will receive neither premiums nor discount. Bales with mike readings in the 37 to 42 range will receive a premium and bales below 35 or above 49 will be discounted. The amount of the premium and discounts will be announced in the spring. Thirty-six percent of the 1989 crop was in the 37-42 range while seventy-eight percent was in the 35-49 range. Both the change in the marketing system and the increased consumer demand for high count, all-cotton garments will increase the demand for fine (moderate mike) bales.

Fiber Development

Cotton fiber develops in an orderly, precise pattern. Starting the day of bloom, cells on the surface of the ovule (unfertilized seed) start to elongate outward into the watery boll. These elongating cells will reach their final length in approximately 16 to 20 days, at which time they start to thicken. Thickening of lint occurs from the daily deposition of cellulose strands in the cell wall. Unlike tree growth where annual rings are deposited outside of last year's growth, cotton's daily growth rings occur inside the previous day's growth. These daily rings of cellulose strands are deposited at different angles, giving it strength similar to fiberglass. If the boll develops to maturity, these layers partially close in the center of the cell or "lumen" in another 20 days.

Once the fiber has reached full thickness or maturity, the last stage in fiber development is drying, causing the fiber to twist and crimp. Crimp derives from the contortion between the daily layers of cellulose. As these layers dry, they shrink in different directions resulting in the crimping that allows cotton to intertwine and be spun into thread. The following diagram shows the development of a single fiber from the seed.



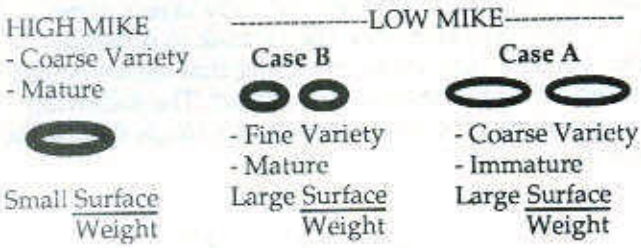
Upland cotton produces another distinct type of fiber called fuzz fibers. The cells that form fuzz fibers start elongating 6 to 8 days after bloom and only reach a short length before they thicken, becoming quite coarse. Fuzz fibers can be a totally different color, as in the old variety "Florida Green Seed" which had white lint and green fuzz.

Micronaire Measures Surface Area

Micronaire measures the surface area of lint. A 3-gram sample (50 grains) of lint is placed in the glass micronaire chamber, compressed to a specific volume and subjected to a set air pressure. The flow of air out the other end of the chamber indicates the surface area and thus the micronaire. Air movement is restricted as it flows next to a surface, in this case, the surface area of the 3-gram lint sample. A high air flow indicates high micronaire and means a small surface area per weight. While a low flow indicates low micronaire and means a large surface area per weight of lint.

Fineness versus Immaturity

There are two totally different routes that lead to low mike cotton. One is the varietal characteristic, fineness. Cotton varieties with fine lint have low mike, even when mature, because they have small diameter fibers and small surface areas (case B, below). As fiber gets smaller, the ratio of surface to weight increases, placing more surface area in the 3-gram sample. The other route to low mike cotton is immaturity, which has a large surface area per weight as the fiber never fills in (case A, below). This inability of micronaire readings to differentiate between fineness and immaturity poses a marketing problem because low mike bales which are fine and mature are highly desirable for production of fine count yarns. On the other hand, low mike bales which are immature are undesirable due to non-uniformity in dyeing and spinning. If a bale's variety is known, micronaire can indicate whether it is mature or immature, because each variety has a specific micronaire associated with it when mature. The following diagrams indicate the size and micronaire of fine and coarse fibers in cross section.



Measuring Maturity and Fineness

Measuring maturity and fineness separately with HVI is a major objective of the AMS Cotton Classing Division. The current HVI systems only measure micronaire, but samples from each classing office are being analyzed on a Shirley Fineness Maturity Tester (FMT IIc) to evaluate their potential use in future HVI systems. Results from these samples are reported in the weekly "Quality of Cotton Classed under Smith-Doxey Act" available from USDA-AMS , 4841 Summer Ave., Memphis, TN 38122. The following figure provides interpretive values for both FMT-Maturity and FMT-Fineness. Since mike will eventually be replaced by a system such as this, producers are encouraged to compare the maturity and fineness of their region's crop to the U.S. crop.

Interpretive Values for Maturity Ratio and Fineness

Maturity Ratio		Fineness	
below .80	Immature	below 150 millitex	Fine
.80-1.0	Intermediate	150-175 millitex	Intermediate
above 1.0	Very Mature	above 175 millitex	Coarse

To illustrate the relationship between mike, maturity and fineness the following example lists the quality for the Harlingen TX, Rayville LA, Macon GA and Birmingham AL crop classed as of 9/13/90.

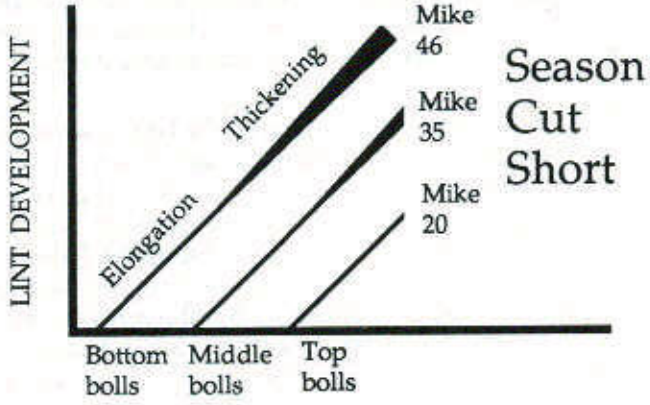
Even though both the Harlingen and Macon crops have similar maturities, the micronaire is significantly different. The Macon crop is largely DPL90 which is a finer variety (159 millitex) than varieties planted in the Harlingen area (175 millitex). On the other hand, the Rayville and Birmingham crops have the same fineness (163 millitex) but the harvest in Alabama is starting with immature fields (0.89 maturity ratio) and thus a low mike (37).

Location	Mike	Maturity	Fineness
Harlingen	46	1.01	175 millitex
Macon	42	1.05	159 millitex
Rayville	44	1.14	163 millitex
Birmingham	37	0.89	163 millitex

Causes of Low Mike: Season Cut Short

The complex impact of environment and management on fiber development and quality derives from the various developmental stages that fiber is in throughout the plant. On the same day, individual bolls may be just starting fiber elongation, others starting to thicken and others may be completely mature. Whether it is water stress or premature defoliation that impacts the bolls, these influences will have a totally different effect on each stage of boll development.

An early termination of the growing season is the most common cause of low mike cotton, whether its frost or Verticillium wilt or early Harvest Aid application. When the leaves are removed, fiber development stops in 2 to 3 days. Even following a defoliant application, fiber develops for only 5 days, half of the time drawing nutrients from the treated leaves, the other half of the time from the stem and roots. The following figure represents the development of the bottom, mid and top crops, both the elongation phase and thickening phase.

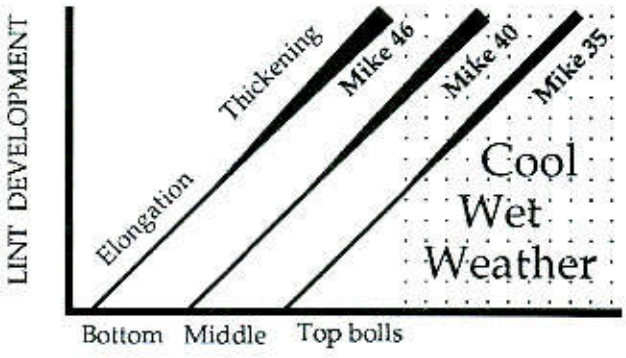


In the following example, the season is cut short. Bottom bolls would be fully mature (46 mike). Mid bolls would not complete full development (35 mike). And top bolls would either not develop enough to open or would be very immature lint and very low mike (20 mike). When all of these boll stages are mixed together at harvest, the result is not only reduced mike but also highly non-uniform lint. This greater non-uniformity with low mike versus high mike cotton increases breakage and dye problems in the textile mill.

Causes of Low Mike Cotton: Insufficient Carbohydrate to Meet Boll Demand

When cotton sets more bolls than it has carbohydrate supply to fill, low micronaire often results. Potassium (K) deficiency is just one example. Unlike nitrogen deficiency, a condition under which the crop will compensate for the lower nutrient level by adjusting the boll load downward, potassium deficiency is created by the crop set on the stalk. Potassium deficient plants set bolls normally, but once on the plant, the bolls' high demand for K exceeds the infertile soil's ability to supply K. The K demand of the developing bolls then strips the potassium from the leaves causing them to bronze and senesce prematurely. Thus K deficient cotton has insufficient carbohydrate supply to mature the bolls and often has extremely low micronaire (reduced maturity). Potassium is directly involved in the physiology of fiber elongation and thickening, thus K deficiency reduces not only maturity but also strength, length and uniformity.

Other factors that create a condition of low carbohydrate in relation to boll demand include: dense stands, high nitrogen, excess irrigation or favorable fruit set. Dense stands and excess nitrogen or irrigation promote vegetative growth and large plants. The shading of lower bolls and leaves reduces the carbohydrate available to mature these bolls. As a result, cotton which is dense or over-watered or over-fertilized with N often has lower micronaire. In the following diagram, cool wet weather has lowered the carbohydrate supply at the end of the boll maturation period causing lower mike in the middle and top bolls.

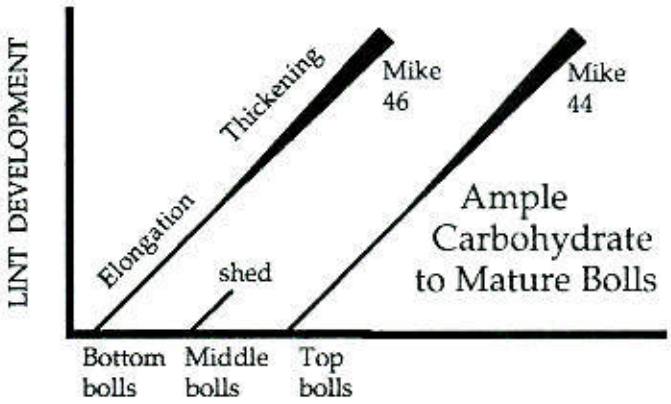


Moderately cool weather during the second half of the boll-setting period also reduces micronaire, because it promotes heavy fruit retention. If the weather doesn't turn hot causing severe boll shed, the heavy boll set will exceed the leaves' ability to mature, and lower micronaire results. Invariably, years with excellent boll retention are low mike years.

Causes of High Mike Cotton: Ample Carbohydrate to Mature Bolls

The micronaire of cotton tends to increase when there is ample supply of carbohydrate to mature the bolls set on the plant. When supply is greater than demand for carbohydrate, the daily rings of cellulose are thicker thus resulting in fiber that fills in the lumen more completely. The most common causes of high mike cotton are poor boll set or small boll size due to hot weather or water stress. High temperatures cause small bolls to shed, and the remaining bolls often have low seed counts; yet the supply of carbohydrates is often increased. We see this in the high temperature years when irrigated cotton gets very tall due to ample carbohydrate and reduced boll load. Water stress often causes high micronaire because boll retention is very sensitive to water stress, while fiber thickening is much less sensitive. When a plant experiences water stress, it sheds young bolls leaving the few older bolls on the plant with ample carbohydrate to fully thicken.

Early-set bolls also have higher micronaire because they are maturing when the days are longer and temperatures more favorable for photosynthesis. Additionally, bolls set at the first position on the mainstem are higher in micronaire because they have more leaves to feed them and they are less likely to be shaded. Thus early crops with high retention at the first position tend to be higher micronaire than later set crops farther out on fruiting branches (Kerby 1988). The following example shows the fruit shed from water or heat stress during peak bloom. The middle bolls shed, leaving ample carbohydrate to mature the bottom bolls or any late-set bolls.



Causes of High Mike: Short Fiber

When fiber is shortened, micronaire often goes up. If fiber elongation is limited, then during the thickening phase, the same quantity of carbohydrate will be spread over a shorter length and allow thicker daily rings. Invariably, short fiber varieties are coarser and have higher mikes when mature than long fiber varieties. Even on one seed, the shorter fibers will be thicker. Water stress during bloom, a major cause of low yields in the 1990 crop, increases micronaire by both shortening fibers and shedding bolls.

Surface Area Changes

The previous causes of high and low mike primarily influence the inside of the fiber and determine how well the fiber fills in. These control mike because they set the number of fibers necessary to make up the 3-gram sample in the micronaire chamber. But micronaire also can be controlled by changes in the surface of cotton lint. An example of changes in surface area is the microbial degradation of lint left to weather in the field. When we see lint grey and darken, it is because fungi are feeding on the lint. This feeding creates a rough surface that retards air movement in the micronaire chamber, causing weathered cotton to suffer a reduction in micronaire.

Another example of surface area changes is in varieties with inherently fine fiber. Lint from these varieties, even when fully mature, have small diameter and perimeter. As fiber gets smaller, the ratio of surface to weight increases, placing more surface area in the 3-gram sample. We do not anticipate that producers will select varieties based primarily on their average micronaire. Unlike strength, the variety makes only a small contribution to micronaire. Additionally, some of the management inputs to lower micronaire also tend to decrease yield. Nevertheless, producers can use mike to identify agronomic practices that decrease yield. Producers should look closely at fields that produce either high or low mike to identify the cause of abnormal micronaire, because an abnormal mike often indicates that yield was limited by either fruit set or the plant's ability to fill bolls.

About the Authors

Ken Bragg is the Research Leader at the USDA Cotton Quality Research Station in Clemson, South Carolina. Work at this station focuses on enhancing ti textile mills utilization of U.S. cotton. Ken's quality research currently includes the causes of "white specks" and neps. Jack Mauney has retired, in name only, from the USDA Phoenix Lab, but has not slacked off in his vigorous research, writing and speaking schedule. Current major research areas include the "white speck" problem and the effect of atmospheric and irrigation water CO_2 on cotton production. Bob Metzer is the Texas Cotton Specialist stationed at College Station. Bob will be retiring next year after a distinguished lifelong contribution to Texas cotton producers.

HVI Quality Meetings for Mid-South

The USDA and Mid-South Extension Services in cooperation with the NCC Physiology Program will be holding meetings on "Adapting to HVI" in Monroe on Dec. 4, Pine Bluff on Dec. 5, Greenwood on Dec. 6, and Memphis on Dec. 7. More details on these important meetings will follow in future newsletter issues.

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