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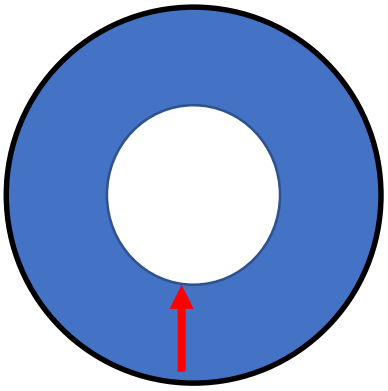
Deep Dive into Fiber Quality Series – Micronaire

Micronaire is complicated. By definition, it is a unitless measure of air flow through a specific mass of fibers compressed to a specific volume. In actuality, the result obtained is a confounded assessment of both fiber fineness and maturity. To gain a better understanding of micronaire, the cotton fiber's developmental timeline must be considered.

- As noted in the earlier Staple article (see October 31 newsletter): If seed is not set, fiber can't be produced. Each cotton fiber arises from a single epidermal cell on the seed coat, and is composed mostly of cellulose.
- After the ovule (seed) is fertilized the primordial fiber tubular structures elongate much like a balloon expands as it is inflated. This first phase is called the elongation phase and it continues for about 20 days or so.
- After that occurs, the second phase of fiber development begins, and it is called the fiber secondary cell wall thickening phase. This phase lasts an additional 25 days or more, and is temperature/photosynthesis dependent.
- Genetics determines about 41% of micronaire potential, with environment contributing the remaining 59%.
- The tubular structure (primary wall) fills from the inside, with daily deposition of cellulose in what's called the lumen. This thickens the secondary wall of the fiber.
- Unlike tree rings, which are deposited outside of last year's ring, the secondary wall of a cotton fiber fills from the inside.
- A good analogy is that the tube (fiber) can be thought of as a drinking straw. The length (i.e. fiber length) and diameter (i.e. fiber perimeter) of the straw are controlled by genetics and environment.

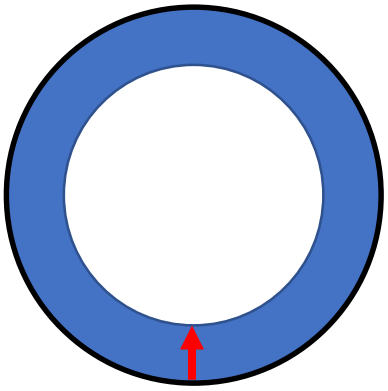
- Fiber diameter is set before elongation begins and is more heritable than either length or strength.
- Thickness of the wall of the straw is also controlled by genetics, but to a greater degree by environment.
- After about 20-25 days of thickening of the wall, the cellulose nearly fills the void. This sets the thickness of the wall of the straw.
- If an excessive amount of the void is filled by cellulose, or if the diameter of the straw is too large, this typically results in HIGH micronaire.
- If the fiber development (or perhaps a good descriptive term such as void fill) is cut short by excessive water stress, lack of heat units (for late-set bolls) necessary to optimize photosynthesis and thus carbohydrate production (cellulose deposition), then LOW micronaire is a typical result.
- Hypothetical cross sections of two cotton fibers with the same diameter are shown below. The one on the left represents a nearly mature fiber and shows the thickening of the fiber secondary wall. The one on the right is less mature and shows a thinner fiber wall. These two examples could represent fibers that are the same age in days, but the one on the right might have fewer heat units and less cellulose deposition due to reduced photosynthesis.

More Mature



Fiber fill starts inside black ring and works toward the center as daily deposition of cellulose occurs

Less Mature



Fiber fill starts inside black ring and works toward the center as daily deposition of cellulose occurs

- The micronaire value that is measured is a result of several factors which interact to impact the flow of air through the fixed sample mass compressed to a known volume. Those include fineness of the fiber (linear density) and its maturity (degree of secondary wall development).

USDA-Agricultural Marketing Service Classing Procedures for Micronaire

- An airflow instrument is used to measure the air permeability of a constant mass of cotton fibers compressed to a fixed volume. A 10-gram sample of lint is placed in the micronaire chamber, compressed to a specific volume and subjected to set air pressure.
- Technically, micronaire is proportional to the inverse of the surface area^2 of a fixed mass of lint.

- The flow of air out of the other end of the chamber is measured and this indicates the micronaire. Air movement is restricted as it flows next to a surface, in this case the surface area of a 10-gram lint sample.
- A HIGH air flow indicates HIGH micronaire and means a small surface area per unit weight of fiber.
- A LOW air flow indicates LOW micronaire and means a high surface area per unit weight of fiber.
- Standard Fineness (or fiber perimeter) is a varietal characteristic.
- Some varieties with small fiber perimeter have lower micronaire, even when mature.
- As fiber gets smaller, the ratio of surface to weight INCREASES, placing more surface area in the 10-gram sample.
- For research purposes, Fineness and Maturity Ratio can be measured using Advanced Fiber Information System (AFIS) machines.
- For an excellent explanation of the US classing system, click on the Cotton Incorporated link below: https://www.cottoninc.com/wp-content/uploads/2017/02/Classification-of-Cotton.pdf
- For a companion document from USDA-AMS that discusses classing data, click on the link below: https://www.ams.usda.gov/sites/default/files/media/Cotton%20DB%20Understanding%20the%20Data.pdf

Causes of High and Low Micronaire

As noted before, micronaire is significantly controlled by genetics, but production environment also has high impact.

- In our area, high micronaire can be attributed to drought stress reducing the boll load on the plants and then later rainfall and fiber maturing temperatures occur. The high amount of leaf area generates a large amount of photosynthates that can fill the remaining few bolls per plant.

Low micronaire can have multiple causes including but not limited to:

- Mis-timed harvest aid applications (too early) by incorrect evaluation of overall crop maturity. In this case, too many bolls do not have adequate maturity for harvest aid applications.
- Lack of solar radiation to maximize photosynthesis (cloudy conditions for an extended period).
- Excessive boll load set for the amount of fiber maturing weather remaining in the season. This is the classical “clock runs out” situation. Not enough heat units have been nor can be obtained to mature the late boll load.
- Early freezes or temperatures slightly above freezing can terminate fiber development. This is most severe when a large number of remaining bolls lack adequate maturity.

- Potassium deficiency can result in low micronaire.
- Excessive nitrogen fertility and high soil moisture can reduce micronaire. This can arise from high residual nitrates in the soil profile, not recognizing mineralization of nitrogen from the organic nitrogen pool in the soil, and/or excessive nitrogen fertilization. High growth potential conditions can delay crop maturity and negatively impact micronaire.
- Excessive drought (moisture) stress during boll fill. If plants severely wilt for an extended period during the secondary wall thickening phase, the fiber development may be terminated or significantly reduced. This results in bolls which do not fluff upon opening.
- Verticillium wilt disease can also reduce micronaire of lint from infected plants. If a large number of plants have this disease, it can reduce overall micronaire for the field.

Reasons for Micronaire Discounts

- Excessively mature (high micronaire) cotton has limited use in textiles due to the fact that fewer fibers can be included in a cross section of yarn. This limits the yarns that can be made with high micronaire fibers to coarse types.
- Low micronaire fibers can impact several yarn and fabric characteristics. Low micronaire fibers can be spun into fine yarns, but immature fibers don't readily absorb or retain dyes. Also, fiber entanglements called neps can be problematic by negatively impacting yarn spinning rates, and can cause white specks in finished fabrics. Neps are typically more pronounced in low micronaire cotton.

Impact of Micronaire on Loan Value

Commodity Credit Corporation (CCC) loan values are affected by micronaire. The premium range only applies to micronaire values 3.7 to 4.2, and only to certain color grade and leaf grade combinations. No value impact is noted in the base range (3.5 to 3.6 and 4.3 to 4.9). All other micronaire values are in the discount range. Cotton gets discounted for low micronaire once values of 3.4 and lower are encountered. Extremely low micronaire fiber has significantly greater discounts which maximize at -1670 points per pound. High micronaire discounts trigger at 5.0 and maximize at -380 points per pound for 5.3 and above. Premiums and discounts (in points per pound) for micronaire are noted in the table below.

Micronaire Values and Associated 2019-2020 CCC Loan Discounts and Premiums

2.4 and lower Discount Range	2.5-2.6 Discount Range	2.7-2.9 Discount Range	3.0-3.2 Discount Range	3.3-3.4 Discount Range	3.5-3.6 Base Range	*3.7-4.2 Premium Range*	4.3-4.9 Base Range	5.0-5.2 Discount Range	5.3 and above Discount Range
-1670	-1240	-815	-535	-360	0	10	0	-230	-380

***Premium applies only to white grades 11-41 with leaf grades 1-6; 51 with leaf grades 1-5; light spotted grades 12-32 with leaf grades 1-5; 42 with leaf grades 1-4; and 52 with leaf grades 1-3.**