

COTTON PHYSIOLOGY TODAY

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THE 1993 COTTON CROP — QUALITY TRENDS

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The next two newsletters are devoted to looking back over the last season to reflect and learn from the crop. This issue will review several quality factors and compare 1993 cotton quality to long-term trends.

The U.S. cotton crop enjoys a well-deserved reputation for high quality. This achievement represents a concerted effort on the part of breeders, producers and ginners. Cotton breeders continue to develop high yielding varieties with improved quality, particularly fiber strength. Growers have modified their variety mix and cultural practices to produce lint with desirable properties. Ginners, working with producers, are developing ginning options that help maintain this quality.

Lint yields in 1993 were mixed and disappointingly low in many production areas. Fortunately, lint quality did not follow this trend. The quality of the 1993 crop set new records in length, length uniformity and strength. The higher micronaire recorded in the year's crop reflected environmental conditions that allowed full development of finer fiber.

Staple Length

Importance to Spinning: Staple length has long been considered one of the primary determinants of cotton quality with good reason. Staple length influences yarn strength and yarn uniformity or evenness. Individual fibers become yarn through various techniques that twist the fiber strands. Longer fibers can twist around each other more than shorter fibers. This layering reinforces the yarn, making it more resistant to breakage. Thus, yarn made from long fibers is stronger than yarn made from short fibers.

Factors Influencing Length: Staple length is primarily determined by variety. Certain varieties produce longer fibers than others. For instance, the premium quality of Pima cottons is partly due to their staple that averages 46 (1.44 inches). However, environmental influences such as temperature, water and potassium availability can modify a variety's genetic potential for this fiber trait. Extreme heat or uncommon cold can limit fiber length. Temperatures drive the plant's metabolism. Cold weather will slow cell expansion, although in mid-summer this is probably not a

consideration. On the other hand, extreme heat during the day and/or night will limit the availability of carbohydrates for cellulose production. This may reduce overall staple length if the plant is under drought stress or if nighttime temperatures are abnormally high.

Both potassium and water are needed for cell expansion or, in this case, fiber elongation. Potassium deficiency during the first 16 to 25 days of boll development can limit fiber elongation within a given boll. Compared to yield, staple length is less sensitive to drought. Water stress that is sufficient to significantly reduce fiber length will have a more profound affect on boll numbers and yields.

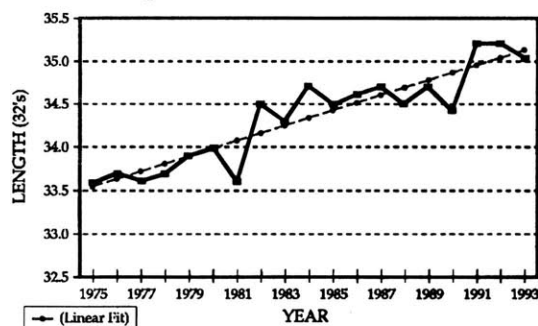
Mechanical damage during ginning and lint cleaning can also reduce fiber length. When lint is over-dried, breakage is increased and average staple length is decreased. Over-drying is more likely when cotton differing in moisture levels is ginned at the same time. One may be over-dried and unnecessarily damaged in an effort to adequately dry the other.

Measuring Length: High Volume Instruments (HVI) measure and report fiber length as the average length of the longer one-half of the fibers, referred to as upper-half-mean length or UHM. A sample of fibers is collected, combed and brushed to create a "beard" which is passed across an electronic sensor. The information from this electronic sensor is used by the computer in the HVI to compute the UHM and length uniformity index. The UHM relates closely to the manual classer's staple.

Trends in Staple Length: The 1991 crop set a record for the longest staple length since these records began in 1940. The 1992 crop was less than 0.001 inches below the 1991 record. With 95% of the crop classed, the 1993 crop is equal in length to that record of 1.10 inches. As the long term trend line in the chart below indicates, staple length has been increasing at the rate of about 1/32 of an inch (.03 inches) each 10 years. This indicates that breeders are developing and producers are planting varieties with superior length. The drought and higher than normal nighttime temperatures may have been factors in minor staple length reductions observed in the Southeast and Mid-South.

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LONG TERM LENGTH TREND U.S. Upland - Dec. 23 - 14,514,632 Bales



Length Uniformity

Cotton fibers come in a variety of lengths. These fibers vary in length due to their biological origins and the ginning process. Length variation is a fact of life. The individual cells that make up each fiber strand elongate independently of one another. This is natural variation. The ginning process creates additional variation when individual fibers are broken, particularly if ginned and cleaned at moisture levels below 6%.

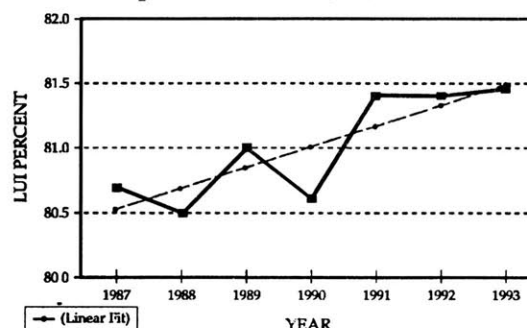
Fiber breakage reduces length uniformity and increases the short fiber content. Spinning efficiency, yarn evenness and yarn strength are decreased when length uniformity is decreased. Uniformity index is also an indication of short fiber content (fiber shorter than $\frac{1}{2}$ inch). Cotton with high short fiber content is undesirable for spinning high quality yarn.

Length uniformity is determined in HVI systems by dividing the average length of all the fibers in a sample by the UHM. Two cotton samples could have the same UHM but quite different length uniformity depending on the amount of short fibers in each sample. A length uniformity of 85% or better is considered very high. Average length uniformity ranges from 80 to 82%.

Trends in Length Uniformity Index: This is the seventh year that length uniformity index data have been supplied in crop reports from the USDA. The 1991 and 1992 crops had the highest length uniformity index on record. At this time, the national average for length uniformity index for the 1993 crop is 81.5%. If this average is maintained throughout the remainder of the ginning season, the 1993 crop will have the best length uniformity of any crop since these records began in 1987. As shown in the chart below, the trend line indicates that length uniformity index is increasing at the rate of approximately 0.2% per year.

The data suggests that growers and ginners are keeping an eye on timeliness of harvest and are paying careful attention to ginning. The continued improvement in length uniformity also may be related to a corresponding increase in fiber strength.

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Strength

The cotton industry has focused tremendous attention on fiber strength in recent years. This emphasis has been stimulated by advances in spinning technology that have enabled mills to increase output and worker productivity. Mills have doubled the output of spinning frames, increased weaving speed seven-fold and replaced slower ring spinning equipment with faster rotor spinning machinery. Higher speeds in textile processing place greater demands on fiber strength.

Rotor spun yarn with less organized twisting relies less on length and more on the strength of the fiber to achieve a given yarn strength. Rotor spinning, which is 3 to 5 times faster than ring spinning, produces yarn with 10 to 15% less strength. Initial fiber strength must be higher to compensate for this side effect of the faster spinning process. Even faster technology, including air jet spinning, also relies on stronger fiber strands for optimum machinery efficiency.

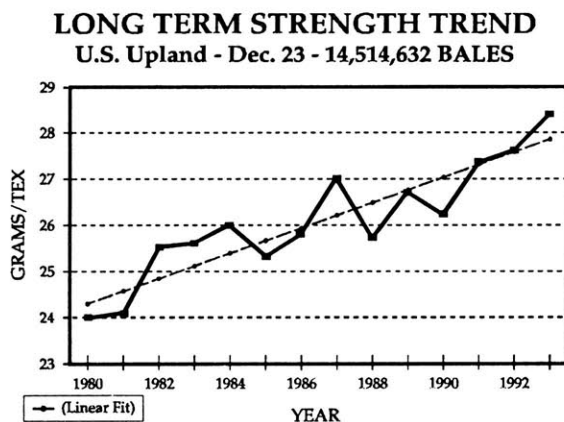
Fiber strength also affects the types of cotton products that can be made from yarn produced by the different spinning machinery. Each product uses yarn with certain properties. One property, yarn size, is measured in counts. The count of yarn is an indication of the length of yarn weighing one pound. Yarn length is measured in hanks or 840 yards. One pound of low count yarn (10) would be 10 hanks long or 10×840 yards = 8,400 yards. For comparison, one pound of 40 count yarn would be 40×840 yards = 33,600 yards long. The higher the count, the finer the yarn. Dress shirts contain high count yarn and require longer, stronger and finer fibers than lower count coarser yarns used for jeans or towels.

To measure strength, the same beard used in length measurement is clamped between two sets of jaws that are $\frac{1}{8}$ inch apart. The jaws are separated and the force in grams required to break the fiber bundle is measured. The fiber bundle strength is obtained by dividing the breaking force in grams by the fiber linear density, measured in tex units. A tex unit is equal to the weight in grams of 1,000 meters of fiber length. Thus, the fiber strength is reported in grams per tex.

Factors Affecting Fiber Strength: Fiber strength is primarily determined by variety. Certain varieties routinely have higher strengths than others. Cotton fiber is composed of cellulose. Longer strands of cellulose molecules with more cross linkages between strands create stronger fibers.

Fiber strength also is affected by environmental influences. Seasonal and regional variations in strength within a variety are recognized but not well understood. Avoiding severe potassium deficiencies and excessive field weathering will help to maintain the inherent strength of the variety.

Trends in Strength: The 1992 U.S. upland crop produced a record average strength of 27.7 grams/tex, exceeding the previous record of 27.5 set by the 1991 crop. The 1993 crop could set a new high strength record. The national average is at 28.5 g/tex with about 95% of the crop tested. Since HVI strength records were started in 1980, the annual increase in strength has been just over 0.25 grams/tex per year. The 1991, 1992 and 1993 crops are slightly above the long-term trend line for strength increase. This probably reflects significant increases in plantings of higher strength cotton varieties. Premiums and discounts have been paid for fiber strength since 1991.



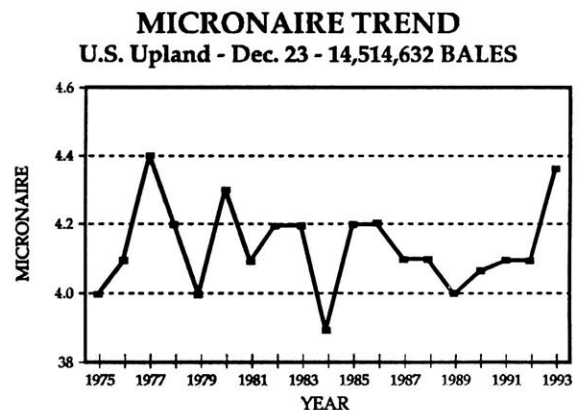
Micronaire

Micronaire is a useful but complex measure of cotton quality. It indirectly measures the combination of fiber maturity and fineness. Micronaire measures resistance to air flow which indicates the total surface area per gram of lint. A sample of lint is weighed, placed in the micronaire chamber, compressed to a known volume and subjected to a standard air pressure or air flow. Air flow is reduced or impeded by greater surface area (finer fibers). As surface area decreases, more air can pass through the chamber, indicating a higher micronaire (more coarse fibers).

Micronaire can indicate fiber maturity. As fibers mature, their hollow centers fill with successive layers of cellu-

lose. Therefore, weight is added without markedly changing the diameter or perimeter. For example, two immature fibers might weigh the same as one fully mature fiber but have twice the surface area. The immature fibers would restrict more air and result in a lower micronaire. Low micronaire in this case indicates immaturity. Within a given variety or closely related family of varieties with similar fiber perimeters, this technique is effective. However, the technique has limitations in determining maturity when comparing markedly different varieties.

Fiber diameter/perimeter is genetically determined. Some varieties produce thicker fibers than others. As fiber perimeter increases, the surface area-to-weight ratio decreases. In other words, there is less surface area per gram of lint with coarser fibers, hence more air flow and higher micronaire. Two widely different varieties could be equally mature but have radically different fiber perimeters and therefore radically different micronaire values. At the other extreme, an immature coarse fiber could present the same surface area and micronaire as a fully mature group of fibers from a fine-fibered variety. Micronaire measurements are best viewed as estimates of fiber maturity.



Difficulties are encountered if micronaire is either too low or high. Low micronaire can indicate fiber immaturity. These immature fibers tend to be weaker and more prone to breakage, creating small knots of tangled fibers called neps which will not dye evenly. High micronaire cotton also has limited uses. A minimum of 100 cotton fibers per cross section are required in the spinning process to hold yarn together and give it strength. High micronaire cotton makes a coarse, thick yarn that limits its use in end products.

Factors Affecting Micronaire: Micronaire is the quality attribute most affected by environment. Factors that affect fiber development affect micronaire. Fiber development is driven by temperature, light and the availability of nutrients, carbohydrates and water. Successive layers of cellulose are deposited within the fiber cylinder. If boll load is high, the availability of carbohydrate to feed the

boll and produce cellulose is tempered by the demand. If boll load is lessened due to transient drought stress, etc., then carbohydrate supply can exceed demand and allow ample cellulose deposition and potentially higher micronaire. Sunlight intensity is increased when plants are smaller, which increases photosynthesis and the carbohydrate supply to the developing fiber. Cool temperatures slow metabolism and cellulose deposition. The result of this temperature effect is seen in the lower micronaire of late-maturing top cotton.

Trends in Micronaire: The national average for micronaire for the 1992 crop was 4.07. The overall average for all cotton crops since 1975 is 4.12. The 1993 crop has an average micronaire of 4.36 with about 85% of the crop classed. If the national average continues to stay this high, the U.S. will have the highest average micronaire in over 15 years. Only in South Texas and in the San Joaquin Valley of California are micronaire values lower in the 1993 crop than in the 1992 crop.

The interpretation of the 1993 trend in micronaire is complicated by the complex interaction between fiber fineness and maturity. However, increases in micronaire recorded in 1993 suggest that cotton varieties approached their full genetic potential this past season. In other words, the cotton was fully mature. High mi-

cronaire strongly suggests that hollow, incompletely developed fibers are at a minimum. Fully mature fibers have the highest quality, irrespective of micronaire values.

Data from random samples taken each week from each classing office and tested by a IIC-Shirley Fineness and Maturity Tester (FMT) support this view. This instrument can separate fiber fineness from fiber maturity to give measures of each. The FMT data shows a 4% reduction in millitex fineness in the 1993 crop compared to the 1992 crop (173 vs. 166 millitex), indicating fibers are **not** coarser this year. Rather, the maturity ratio is up 12.2% for the '93 crop compared to the '92 crop (1.01 vs. 0.90), indicating additional cellulose deposition in the interior of the fiber cylinder.

Wrap Up

Great strides have been made in cotton quality in recent years. The 1993 crop has accelerated this pace by setting new records to shoot for next year. This effort on the part of breeders, producers and ginner was made in response to the expressed needs of the textile industry and demonstrates how cooperation can preserve and enhance the recognized value of U.S. cotton.

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