

Germinating ideas

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QUALITY AND AUSTRALIAN COTTON

The excellent fibre quality of the CSIRO cotton varieties has been critical in Australia establishing its international markets. In this edition of Germinating Ideas, we look at some of the important fibre parameters, why they are important, and the advances that have been made through plant breeding.

Fibre length and uniformity

Staple length affects the ability of the cotton fibre to hold together in yarn. Longer staple allows finer and stronger yarn. Each fibre will traverse more twist in the yarn and there will be fewer breaks between fibres.

High Volume Instrument (HVI) measurement of length is made on a combed "beard" or tuft of lint which is inserted into a scanner.

The principal length measurement made is the upper half mean length (UHML) which is the mean length of the longest 50 per cent of fibres in the beard. It is reported in decimal inches, and converted into 32nds of an inch.

At the same time, the mean length of the whole sample is determined. The ratio between this mean length and the UHML, when expressed as a percentage, is known as the Fibre Length Uniformity Index.

If all fibres in the sample were the same length, the index would be 100 per cent. The lower the index value the higher the percentage of short fibres in the sample. Cotton with low uniformity becomes more difficult to process and is more likely to produce low quality yarn. No financial disincentive currently applies for low uniformity. But when base length falls below 13/32 inch, the cotton attracts a discount.

Micronaire

Micronaire is a measure combining fibre fineness (outer fibre diameter) and fibre maturity. Fibre maturity is the ratio of cotton cell wall thickness to maximum wall thickness when growth is completed.

The micronaire instrument measures the rate at which air flows under pressure through a plug of lint of a set weight compressed into a chamber. The rate of airflow varies with the degree of

TABLE 1: Staple length conversion

HVI Length (decimal ins.)	Code	Staple Length (ins.)	Staple Length (mm)
0.99-1.01	32	1	25.4
1.02-1.04	33	1 ¹ / ₃₂	26.2
1.05-1.07	34	1 ¹ / ₁₆	27.0
1.08-1.10	35	1 ³ / ₃₂	27.8
1.11-1.13	36	1 ¹ / ₈	28.6
1.14-1.17	37	1 ⁵ / ₃₂	29.4

TABLE 2: Fibre length uniformity index

Degree of Uniformity	Fibre length Uniformity Index (%)
Very High	> 85
High	83-85
Intermediate	80-82
Low	77-79
Very Low	< 77

TABLE 3: Varietal finess and maturity differences

	Solara V-15	Scot 189	Delta Pearl
Micronaire	3.7	3.8	3.8
Fineness (millitex)	134	140	145
Maturity (%)	88	87	86

TABLE 4: Scale of values fibre strength, 3.2 mm gauge (HVI & Pressley)

Fibre strength	Rating (gm per tex)
<24	Very low
24-26	Low
27-30	Average
31-34	High
>34	Very high

resistance the plug offers, which depends on the total surface area of fibres in the sample. Reduced fibre diameter or cell wall thickness results in more fibres in the plug, which causes increased airflow resistance, and a lower reading.

High and low micronaire cotton cause problems for the textile industry and hence are subject to hefty discounts. Low micronaire cotton is usually immature, which affects its ability to absorb dye uniformly and retain dye. It is also more likely to form neps during ginning and processing. So slower processing is usually required. High micronaire cotton has limited use because it cannot be spun efficiently into fine yarns. Micronaire readings in the range of 3.5–4.9 inclusive are base, with discounts applying both below and above this range.

As part of its breeding program, with an emphasis on producing marketable product, CSIRO has endeavoured to select for mature but relatively fine fibre. But these two desirable qualities aren't determinable from HVI testing. Two cottons with the same micronaire value can have different combinations of fineness and maturity. Table 3 illustrates this, the data being derived from 13 CCT sites in 1996–97 — fineness and maturity being measured with a Fineness Maturity Tester (FMT) machine. Note the fineness of Siokra V-15, where the fibre is more mature, even though it has a lower micronaire.

Micronaire remains a strong measure of fibre maturity within a variety however, where fibre diameter is relatively constant.

Colour

When mature cotton bolls first open, the lint is white and clean because cellulose is highly reflective, and there is little microbial degradation of the fibre surface.

As it weathers, it greys due to moisture — both humidity and rain — and fungi start to feed on the fibre surface. The colour of the dark fungal spores greys and dulls the lint. If dry sunny conditions return, the fungal growth decreases. The cotton may lose its greyness, but never fully regains its bloom.

If cotton is dry when it goes into a module, the colour will hold. If seed cotton is stored wet in modules, above 14 per cent moisture in particular, cotton seed respire from microbes feeding on the seed, and tannins are released from the deteriorating seed, discolouring the lint.

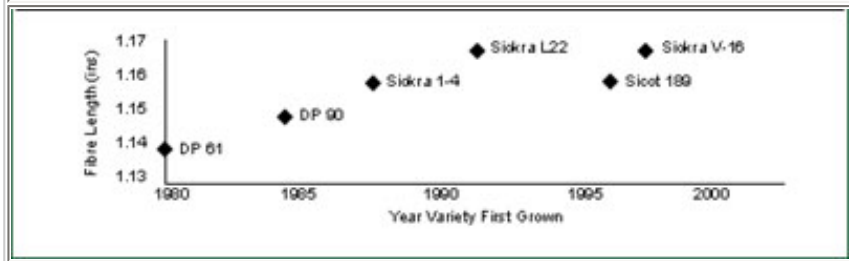
If fibres contact moist green leaves either on the plant or in the module, lint can be stained. These concentrated yellowed patches contribute to light spot and spotted descriptions in grading.

Cotton that is severely discoloured is undesirable to spinners because the deteriorated lint surface

TABLE 5: Improvement in strength

Variety	Year of Release	Strength (gm per tex)
DP 61	1980	24.7
DP 90	1985	27.8
Siokra 1-4	1989	29.0
CS 189	1993	30.0
Sicala 40	1998	31.5

FIGURE 1: Fibre length improvement in Australia



Sample placed for colour measurement with colorimeter and leaf grade with video trashmeter.

TABLE 6: Yield and fibre quality improvements: Sicala 40 over V-2

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Characteristic	Variety		Comment
	Sicala 40	Sicala V-2	
Yield (%)	105.0	100.0	Improvement – 5% gain
Strength (gm per tex)	31.5	30.6	Improvement – increased strength
Uniformity (%)	85.1	84.5	Improvement – higher uniformity
Maturity (%)	85.2	82.9	Improvement – more mature fibre
Fineness (millitex)	143.0	144.0	Improvement – finer fibre
Length (ins.)	1.17	1.19	Reduction in length – still satisfactory
Micronaire	3.81	3.74	Improvement – higher micronaire
Short fibre (%)	5.8	6.2	Improvement – less short (<13mm) fibre
Colour ('b' number)	2.89	3.07	Improvement – reduced yellowness

is rougher, affecting fibre movement in processing. As well, fibre breakage may occur. Fibres may be affected in their ability to absorb and hold dyes.

Colour is measured by HVI as the degree of greyness or reflectance (Rd) and the degree of yellowness or pigmentation (+b). The various combinations of grey and yellow are converted into a colour grade using a Nickerson–Hunter diagram. In most years, Australian cotton has high reflectance values of 72–82, low yellowness of 7–9, giving colour grades of strict middling (21), middling (31) and strict low middling white (41).

Fibre strength

New high speed spinning techniques give higher production output and lower costs. But stronger fibre is required to minimise breakage rate and produce yarns of satisfactory strength. High strength fibre is also associated with other important quality parameters such as length uniformity.

Fibre strength is reported in units called grams per tex. It represents the force required to break a bundle of several hundred fibres one tex unit in size. A tex unit is the mass in grams of 1000 metres of fibre. The HVI measurement is made on the same beard of lint used for length determination, by clamping the bundle in two sets of jaws, 3.2 mm apart, and increasing the separation force until the bundle breaks.

Variety contributes to 80 per cent of the total variability in strength. Varieties with strong fibres tend to produce longer cellulose molecules, which provide fewer break points in the lint, and greater cross linkages.

Table 5 indicates the improvement in strength in representative varieties on offer to Australian growers over the past 20 years. As with staple length, the CSIRO cotton breeding program has been very successful in producing varieties with greater strength.

Generally, production practices that result in high yield will promote strength. Potassium deficiency is an agronomic factor which can decrease strength by up to two grams per tex.

As with micronaire, late season reduction in leaf carbohydrate production can cause some reduction in strength, as fibre strength increase closely parallels fibre wall thickening. Extreme weathering and over-ginning with excessive heat will also reduce strength.

In low micronaire cotton, strength values obtained by HVI can be artificially inflated, because more (finer) fibres fit into the bundle, thereby increasing the force needed to break the bundle.



Honeydew build-up on leaves late season. (Photo: Cheryl Mares, CSIRO, Narrabri)



Combed beard ready for HVI length and strength measurement.

Trash

Trash represents the non-lint particles such as leaf, bracts, bark and grass. Supplying clean cotton to the gin increases returns to the grower in reduced lint losses and improved fibre quality. This is achievable with successful defoliation to remove leaf and good harvest management.

If trashy cotton comes to the gin, the heavy cleaning can remove not only trash but also lint. It can cause breakages, increasing the percentage of short fibres and lead to the formation of neps. As well, over-ginning to improve grades and thus returns to growers can create increased amounts of very small trash particles, called pin trash.

There are strong indications that modern spinning mills may be less damaging to the fibre than gins in removing some of the trash.

Obviously, this would require a modified system of payments to growers, as more foreign material would be removed later in processing than has been traditional.

Leaf grade is measured by HVI, with a video trashmeter scanning one surface of a sample, to determine the percentage of non-lint particles.

Stickiness

Stickiness is a problem that becomes apparent when certain contaminants present on the cotton fibre begin to interfere with the smooth operation of the carding and spinning process. In addition, sticky cotton usually produces yarns which are weak and irregular in appearance. These sticky sugary deposits, known as "honeydew", are produced either by a feeding insect or by the cotton plant itself.

Between 80 and 90 per cent of all stickiness is attributable to insect honeydew, the main insects involved being cotton whitefly (*Bemisia tabaci*) and cotton aphid (*Aphis gossypii*). Both insects feed on the leaf undersurface, but honeydew deposition occurs on upper surfaces of leaves and bolls.

Honeydew that drips off leaves onto open bolls is not easily seen once it dries. Cotton already contaminated with honeydew may retain vegetable debris, sand and dirt generated by late season storms.

Research is currently underway to develop practical, quick and simple methods of testing individual bales for stickiness. One problem is that even in bales, honeydew often occurs in concentrated aggregations, and thus requires detailed measurement to detect.

Most ginner's reserve the right to pass back to growers any claims which occur as a result of stickiness during later processing.

Neps

A nep is a small site of imperfect cotton. Neps have a very strong influence on the quality of cotton textiles produced. Synthetic fibres suffer few imperfections, and are very uniform in batches. Therefore, cotton buyers are constantly seeking consistent, uniform product to compete.

Three types of neps or tangles of fibre occur. The most important is white speck neps, which are small clumps of cotton fibres resulting from harvesting immature fibre. They cause weak cotton fibre, wastage in combing trying to clean these out and poor quality dyed fabric.

Testing at the CSIRO fibre quality lab at Myall Vale has shown that Verticillium wilt susceptible varieties have higher neps than other varieties in years when the disease incidence is high. Least neps were found in mature, uniform, coarse cotton.

There are two other types of neps. Mechanical neps are likely to occur in weathered cotton during harvesting and ginning. They result in physical defects in fibre.

Biological neps are caused by trash which remains in the cotton lint, often resulting in small, dark specks in finished fabric.

Some degree of measurement for neps is now occurring in most commercial classing laboratories to meet specific buyers' requests for low neps. Current measuring techniques are very slow, reducing the level of testing possible.

Quality improvement and plant breeding

Cotton yield can be lifted by increasing the number of seeds in each boll, the number of fibres per unit of seed surface area and the length and wall thickness of each fibre. But increased wall thickness is counter to spinners' demands for a mature fine fibre.

In fact, the association between most characteristics influencing yield and those contributing to desirable fibre properties are weak, which makes the plant breeder's task more difficult.

Table 6 outlines yield and fibre quality differences between two important CSIRO lines. Sicala 40 was released commercially in 1998 and Sicala V-2 in 1992. Not only does Sicala 40 show a significant yield increase over Sicala V-2, but also an improvement in virtually all key quality parameters.