

NEW APPROACHES TO MEASURING AND EXPLAINING THE CONCEPT OF MATURITY

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Introduction:

Cotton fibre maturity has several definitions. Synonymous with ripeness, maturity may be that property which increases with the reproductive power of the seed, signalling to the plant that the seed containing part is ready to fall off and be blown away to germinate later. A generally accepted definition is that maturity refers to the level of secondary wall thickening that occurs during the latter half of fibre development. The extent of this thickening influences both chemical and physical characteristics of the fibre. The physical scientist, measures maturity as a function of the fibre wall thickness, expressed in some way, such as degree of thickening, that separates the genetic effect of fibre coarseness.

Immature fibres (those fibres with little or no wall development) collapse and become entangled during processing, forming small knots or neps. Neps form during mechanical operations such as machine harvesting, ginning, drying, cleaning and carding. Clumps of fibres with no wall development (also known as dead fibres) and stuck together by plant sugars may exist from the harvesting of unripened bolls and represent another type of nep. Neps incorporated into yarns and fabrics will downgrade the value of the product. Neps also affect dyeability since immature fibres take up less dye causing a spotting effect on the surface of the finished fabric. Thus, to the mill man, maturity has much to do with freedom from neps, which slow production, increase end breaks and detract from appearance. Any fibre, especially if fine, can make neps, but only cotton neps can be associated with immaturity.

Grade*/reflectance	Strength,
Staple length*	Extensibility
Colour*/Yellowness	Non-lint content
Short fibre content	Types of trash*
Linear density	Cleanability
Micronaire* Linear Density	Lint detaching force
Maturity	Cohesiveness

* *Affects Commercial Value*

FIGURE 1: IMPORTANT FIBRE PROPERTIES

Most key fibre properties (Fig. 1) are measured by one or two accepted methods. While arguments about maturity are common, there is so far no accepted commercial measure, so it is not normally a factor in the price of cotton. It is allowed for only to the extent that it contributes to the micronaire value. A low micronaire is commonly interpreted as immaturity, while a high value is seen as coarseness, both of which lead to discounts. As barbados cottons, and arguably fine hirsutum varieties, are in the low-micronaire discount range even when fully mature, these results are sometimes controversial. This has put pressure on industry, and especially instrument manufacturers, to analyse micronaire into its coarseness and maturity components, preferably at the speed of a high-volume line.

Several approaches to measuring maturity are listed in Fig 2, with the researcher's single-fibre methods perhaps the best, but also the slowest. The need for fast and accurate commercial tests has tended to aggravate the diversity, highlighting an undesirable lack of consensus related to the variety of definitions.

A. Estimates:

Micronaire value*

Appearance and feel of lint

B. Measures of Maturity:

Fundamental - swell, examine wall*

Causticaire

Polarised light

Differential dyeing*

Double compression airflow; Arealometer

Shirley FMT

Near infra red reflectance*

Optical density in fibrograph tuft

Optical extinction methods; FFDA*, AFIS

* *Used in TFRI Research*

FIGURE 2: ESTIMATING AND MEASURING MATURITY

The causes of immaturity are almost as many as its definitions. The most obvious is a clash between the time needed for a variety or hybrid to ripen and the length of growing season in a given summer. Once the seed is selected and planted, maturity is probably more manageable than staple length or strength and responds to good farming practices. It is retarded by the penetration of insects and by treatments that force the bolls to open prematurely. In countries where two or three hand harvests are feasible, each picking can be "tuned" to the ripening process from the bottom to the top of the plant. In places where stormproof cottons are grown and stripper harvested, practices are different but the principles of maturation are similar. In Australian conditions, the slower increase in maturity that sets in about 60 days after flowering must be assessed, in the light of the deterioration of almost every

other property if the open bolls are left exposed. The effect of plant senescence on maturity may deserve more attention.

Maturity also correlates with other fibre properties (Fig. 3). Approximately, micronaire is the product of maturity and linear density (or fibre mass per unit length). A fibre harvested before its time is penalised in many ways the linear density may be curtailed, the maturity falls short of potential, the micronaire may lead to a discount and the yield is reduced in proportion. Immature fibres tend to be weak fibres, which are increasingly likely to be devalued. Consequently they tend to be broken in harvesting, ginning and lint cleaning, leading to a higher short fibre content - itself a problem of comparable significance to the Australian industry, and almost as hard to measure.

Linear Density	Resistance to neppiness, mill "low-ups"
Lustre	Strength
Bulk, resilience, "body"	Extensibility
Length uniformity	Deeper shade when dyed

FIGURE 3: CORRELATES OF MATURITY

CURRENT TFRI WORK:

Research at TFRI has focussed on obtaining fundamental measures of maturity from cotton fibre cross sections using an image analyser and relating these firstly to maturity results obtained from newer techniques, including near infra red reflectance (NIR) and, later, to spinnability and dyeability.

TFRI research has been directed to near infra red measurements because of current world-wide interest in this technique. With results claimed to indicate maturity, NIR instruments operate fast and lend themselves to inclusion in HVI lines. Our work has extended previous work by Ramey (1982) and Ghosh (1985), who found good correlations between various measures of maturity and NIR measurements. This brief presentation will consider only the international calibration cottons, excluding the two Asiatic types, but including an Egyptian type, D and an American-Pima, E, the others being Upland cottons, including the immature G. This selection provides a sensible range of properties and makes the experiments reproducible; anybody can buy the same cottons and check our results. These cottons are few enough that only the most important relationships are detected by statistical significance. They also represent a realistic, commercial range of maturities.

Methods, of direct microscopic observation and weighing, are tedious and not necessarily more accurate than the alternatives, but offer the advantage of being

necessarily more accurate than the alternatives, but offer the advantage of being independent and providing a fair base for appraising comparatively the advantages of all other approaches to measuring maturity and linear density.

Examination of fundamental linear density measurements (Fig. 4), shows that they alone give a fair prediction of the known micronaire. The correlation coefficient, 0.928, means that 0.928^2 or 85% of the variation in micronaire is explained by linear density (more crudely, "fineness") alone. When we measured linear density, like micronaire, by an airflow method, the correlation rose to 0.973, but that would be an inbred and unfair comparison. The results are less impressive when viewed in a different light; the standard deviation of the results about the regression line is 17 mtex, so that the linear density of a given cotton is estimated, at best with a 95% confidence interval of ± 34 mtex.

The trap to be avoided is the assumption that micronaire denotes only linear density. Overseas breeders have been known to develop generations of increasingly low-micronaire cotton, only to find partial explanation in producing cotton that had too long a growing season to mature in its location. Maturity, estimated by swelling fibres and measuring relative cell wall thickness (Fig. 5), also correlates well with micronaire. With a weaker coefficient of 0.869, some usefulness of micronaire measurement in measuring maturity is apparent. The standard deviation of estimate is 0.062 units, but we know of no method of maturity estimation that has brought this value lower than 0.04.

If linear density and maturity both correlate with micronaire, they may be expected to correlate with each other. Fig. 6 shows the relationship, which is barely significant. With a standard deviation of 34 mtex, the correlation has little predictive value, but it has great nuisance value. This means, in practice, the risk of thinking that we are measuring maturity when we are really measuring linear density, or vice versa. The development of double-compression instruments required very fine distinctions in analysing the two sets of results. Consequently the percentage errors in estimating maturity and linear density are about three times higher than in micronaire.

Looking again at the graph, we recognise that any procedure for calibrating instruments for either property is doomed to error unless for every level of, eg maturity, we deliberately choose calibration cottons having a range of the other property, i.e. a correlation of about -0.3 to $+0.3$, corresponding to a coefficient of determination below 9%. We see no evidence that this has been done for any of the commercial instruments being marketed. If it has been done, the world of cotton would be well served by these calibration materials being made available.

The spectral responses of the eight calibration cottons at 2100 and 2348 nm were measured using a Technicon Infra-alyser, averaged and are presented in the three final figures. These show that a measure of maturity can be obtained with $r = .896$ (Fig. 7). By judiciously selecting wavelengths, this value can be increased.

In comparison with this value for the NIR method and the previously quoted .869 for the swelling method, we have obtained .875 between double-compression maturity and airflow micronaires measured on the same specimens, .855 between fundamental maturity and the degree of thickening measured by image analysis, but only .413 between maturity and the mean fibre diameter.

Unfortunately it would appear that the NIR results shed as much light on linear density (Fig. 8), making the interpretation of results difficult. Current research at USDA Southern Regional Laboratories is attempting to define the relationships between linear density, maturity and NIR responses. This is therefore complementary to our work.

NIR results correlate even more closely with micronaire, with $r = .976$ (Fig. 9). In view of our remarks about relative precision of the four derived airflow parameters, this should come as no surprise - though it has, to some other researchers. The finding that NIR predicts more precisely a quantity that needs no prediction, does not detract from its usefulness in estimating maturity, especially when further research has better unscrambled maturity from the other properties with which it is commonly associated.

It should be noted that this work is rapidly bringing Australia into line with the rest of the world in terms of quality and relevance of cotton fibre research. This report has described only part of the ongoing research Cotton fibre at TFRI, and is based on the Ph.D. program of Stuart Gordon supported by the Cotton R & D Corporation. We are currently extending these studies and are pleased to be partners in the continuing progress of the Australian cotton industry

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Ghosh, S., Textile World, 45 (1985)

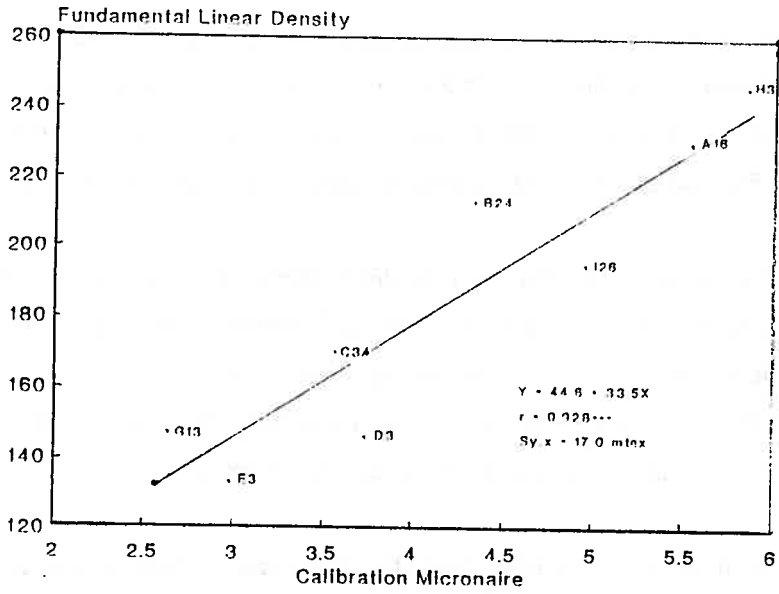


Fig 4 Fundamental Linear Density vs Known Micronaire Value

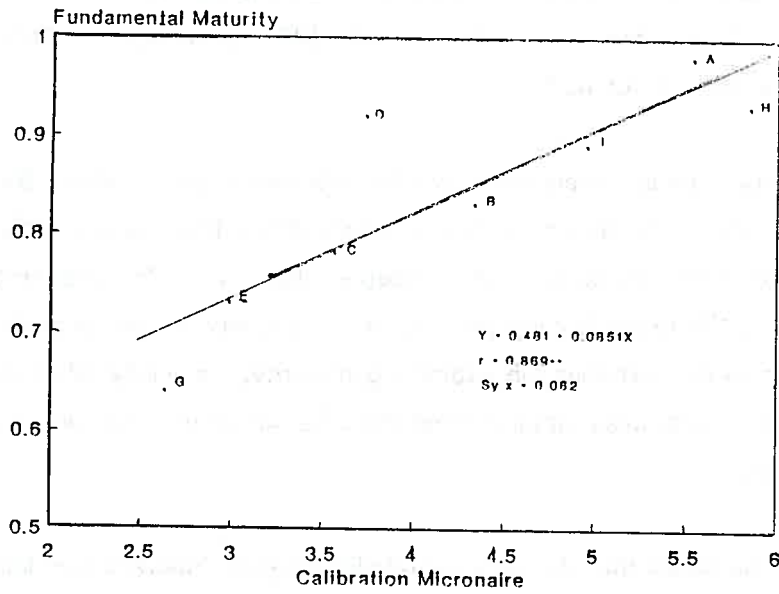


Fig 5 Fundamental Maturity vs Known Micronaire Value

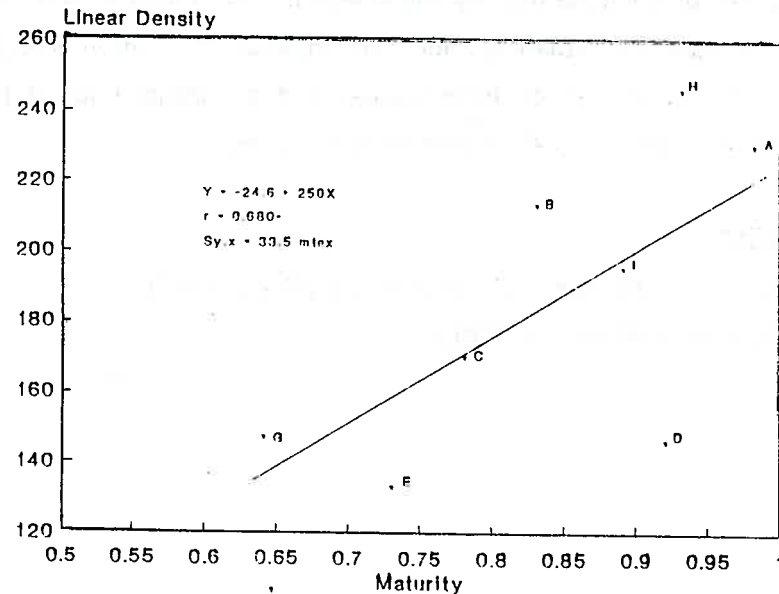


Fig 6 Fundamental Linear Density vs Fundamental Maturity

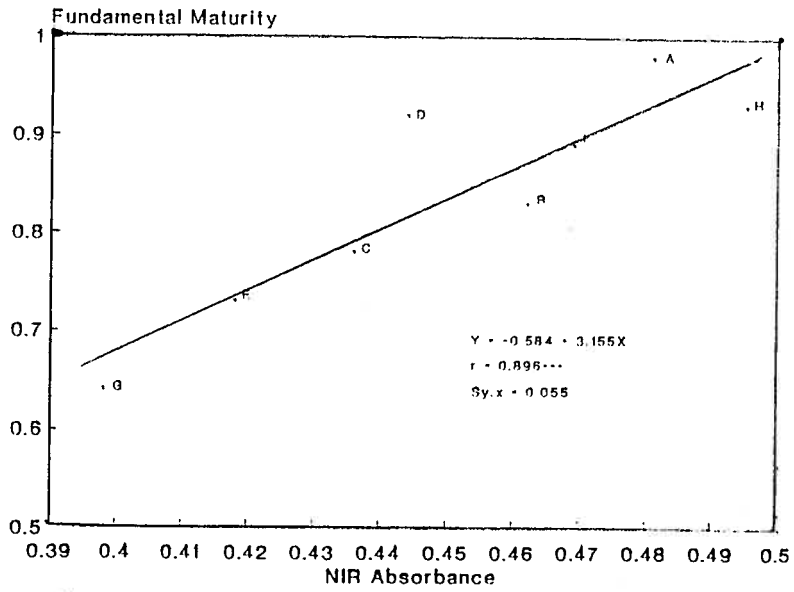


Fig 7 Estimating Maturity by Near Infra-Red Absorbance

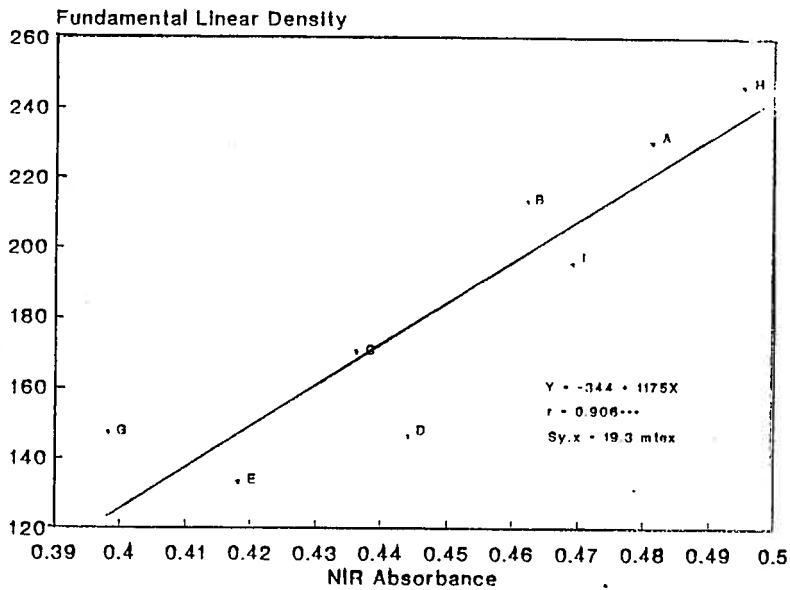


Fig 8 Estimating Linear Density By Near Infra-Red Absorbance

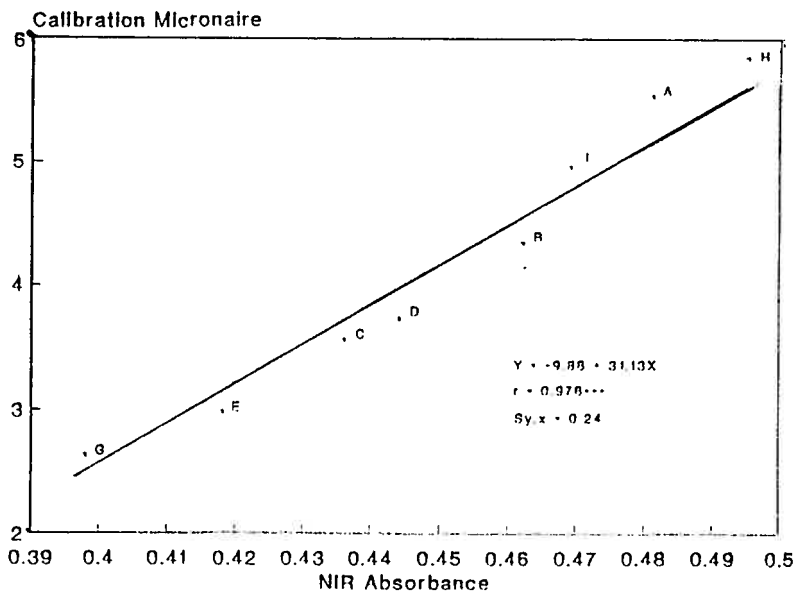


Fig 9 Estimating Micronaire By Near Infra-Red Absorbance

1000 - with 1/2 inch of 1/2 inch 1/2 inch 1/2 inch 1/2 inch

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