# The Future For Better Cottons

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I have been asked to discuss two features of the CSIRO cotton breeding work at Narrabri. The first concerns the quality criteria we use, the second the role that biotechnology will play in varietal improvement.

## Role of quality in selecting improved cotton varieties

At the beginning of this decade it became clear, through contact with domestic and foreign cotton processors, that cotton fibre quality was to become increasingly important and would greatly affect our ability to sell the end product. Traditionally, the emphasis in cotton breeding has been for yield and fibre length - length being the quality character most important for successful ring spinning. The development of faster spinning technology has meant that fibre strength has become the highest priority. In response to this change in demand a breeding programme was initiated to provide replacement varieties for Namcala, whose yield was too low. More recently it has become clear that even faster friction spinning systems will be installed by 1990 and that while strength remains of supreme importance, fibre finess at high maturity will be necessary. Increased fibre length is not required by this technology and our aim is to improve the other characters while leaving length and uniformity the same. Elongation can be an important character in high-speed spinning since higher elasticity enables fibres to be stretched without permanent damage and can, to some extent, improve upon the static strength of the fibre.

The movement towards machine classing in Australia is to be applauded since the ginners are now able to routinely measure strength. Eventually maturity and fineness will be measured by machine too in place of the composite character micronaire. Clearly fibre strength will have to be incorporated into the pricing system and this can now be achieved with high-volume instrumentation (HVI). The experience in Texas is that between US$5 and US$25 per bale can be saved by moving away from hand classing. It is important to be acquainted with the stelometer units of strength, grammes per tex (or g/tex). The relationship between the Pressley test and the stelometer test is not exact since they are measured slightly differently. In the Pressley test the jaws which grip the fibres are actually touching whereas in the stelometer test they are 3.2 mm apart. This means that the Pressley test includes the strength of very short fibres (which the other test does not) and these fibres contribute little to spinning performance. As a result g/tex is a better measure since it more accurately predicts final yarn and fabric strength. The general relationship between Pressley and stelometer is illustrated in Figure 1.

The need for finer fibres means that a mature-fibre micronaire of about 3.0 will be required by processors. At the moment low micronaire is heavily discounted and as genetically low-micronaire cottons become available changes to the tariff system will be required.

The recent decision of CSD not to stock seed of any variety with a fibre strength of less than 88,000 Pressley reflects these new market forces and the action necessary to hold our market share. The rapid and almost total adoption of the two new varieties Siokra and DP90 in only 12 months has shown how important quality requirments have become.

The overall raising of quality standards has affected all our cotton breeding programmes and although they may have different main objectives (eg short season cultivars) the minimum quality standards remain. This does not make the job any easier. In such a high input crop, where the plant is working close to its physiological limit, the law of diminishing returns applies. My view is that the greatest progress in varietal improvment will be made in selecting varieties tailored to particular environmental conditions and that a small number of varieties, perhaps six, might be grown country wide. Although these varieties may vary in their morphology, agronomic requirments, or season length they will all have to produce lint above a minimum quality level.

Cotton breeding is a relatively new business in Australia but we are now seeing increasing numbers of home-produced varieties becoming available. Because US varieties are not deliberatly bred for Australia I see foreign varieties being totally displaced in the not too distant future. For example, bacterial blight is not a problem in the USA where Deltapine varieties are grown and consequently there is no prospect of Deltapine and Land Company breeding blight resistant cultivars.

Our industry needs resistant varieties and so we are producing them ourselves.

There are two other fibre quality characters worth mentioning which may become important, but about which we know very little at the moment. The first is the surface friction properties of the fibres which may be important for improved friction spinning performance. Second the seed-to-fibre attachemnt force which greatly influences the number of fibres damaged in the ginning process. There is genetic variablity available for both these characters and it may need to be exploited in the future.

Role of Biotechnology in varietal improvement

The future for plant breeding in cotton and all crops is exceedingly bright because in recent years molecular biologists have developed powerful new techniques which permit the direct manipulation of hereditary material in all organisms. 'Genetic engineering' is the clumsy and emotive term used to describe such activities; I prefer to use the word 'biotechnology'.

Every cell of every organism contains hereditary material in a specialized and complex molecule whose name is abbreviated to DNA. The DNA contains the blueprint for every component of the organism in a precise chemical code. Biotechnology provides the methods to manipulate this DNA in ways that are normally not possible in nature. Most important is the ability to move DNA from one species to another. Biotechnology is necessarily laboratory-based work but that doesn't mean that there are no applications to the real world. There have already been some spectacular success stories. For example, insulin (needed in the treatment of diabetes) used to be collected from pigs but can now be produced very cheaply in an industrial fermentation plant by genetically modified bacteria.

I will now discuss in some detail an example more applicable to the cotton industry. It is estimated that in the US 15% of total crop production is lost to weed competition - that's a massive US$450 million per year. Powerful herbicides are available to control weeds but their use is usually restricted because of crop susceptibility. Biotechnology provides the mechanism to modify the DNA of the crop species to endow it with herbicide resistance (Figure 2).

Glyphosate (tradename Roundup) is a well known and extremely useful herbicide. Its mode of action is highly specific - it affects one particular biochemical reaction in the pathway of amino acid synthesis. Amino acids are required to build proteins - essential constituents of all organisms. If a plant is poisoned with gylphosate the existing supply of amino acid dries up, the precursors accumulate and the plant dies. Glyphosate will not only kill green plants but bacteria too. The approach of workers in the USA has been to use bacteria as the source of the DNA code necessary to avoid glyphosate poisoning.

A bacterium called Salmonella is normally susceptible to glyphosate. Very large numbers of this bacterium were treated with a chemical which induces changes in the hereditary material called mutations. The treated bacteria were grown in the presence of glyphosate and resistant strains were isolated. The problem then was to extract the small piece of DNA responsible for this new attribute and to transfer it to the chosen target crop plant, in this case tobacco.

A natural DNA transfer system was modified to do the job. Crown gall disease is caused by the prokaryote Agrobacterium, which infects plant cells by transfering a section of its DNA into the plant genome. The genes from Agrobacterium are then treated by the plant as its own, but the new gene products disrupt the normal functioning of the plant cells resulting in the characteristic tumour. This natural DNA transfer method was harnessed by biotechnologists as a vehicle to smuggle foreign DNA into the plant. The transfered DNA was contained in a separate small DNA molecule called a plasmid, and plasmid modification was

the key to the whole process. The Agrobacterium plasmid was altered by removing the genes responsible for the crown gall disease, but leaving intact the sections necessary for successful transfer and incorperation into the plant DNA. The plasmid was then moved into a third bacterium, E.coli, where the gene from Salmonella was waiting; it was previously extracted and placed in a second plasmid. The scientists then caused the two plasmids to exchange pieces of DNA, eventually producing a hybrid containing the Salmonella gene plus the Agrobacterium transfer codes. The hybrid plasmid was then moved back into Agrobacterium which was used to infect plant cells.

Infection took place with the cells growing in tissue culture in the laboratory. Plantlets were then regenerated from the callus tissue and the seedlings screened to see which ones were resistant to the herbicide. The survivors were grown to maturity and then conventional breeding took over. This technique was used by Calgene to produce tobacco plants with a 10 fold resistance to glyphosate. By careful manipulation no unwanted DNA was transferred and the other characteristics of the plant remained unchanged.

It is intended to pursue research of this nature at Narrabri with CRC funding, and glyphosate cotton may be the first objective.

Other examples of successful gene transfer and expression in plants are:

1) soybean seed protein moved into petunia
2) maize enzyme moved into tobacco, and
3) pea seed protein moved into tobacco.

Other herbicides and insecticides are receiving attention, for example, resistance to atrazine and expression of the toxin from Bacillus thuringiensis, and of nitrogen fixation genes from legumes. However, there are still numerous pitfalls to avoid:

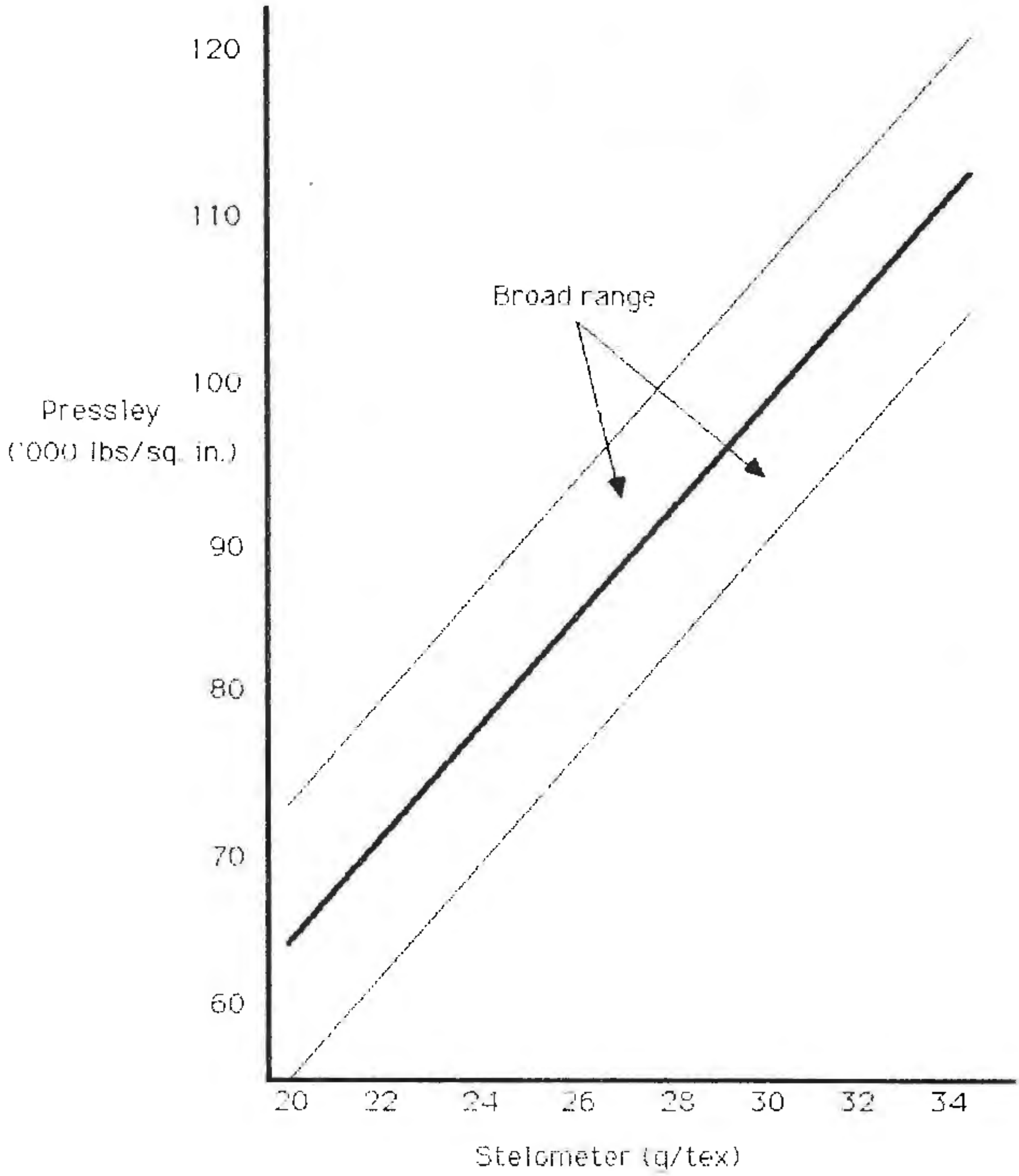
1) The foreign gene must be inserted in the correct orientation for the genetic code to be translated correctly.

2) The gene must be provided with suitable molecular on/off switches called promotors. These often originated from other organisms and are stitched into the plasmid while in E.coli.
3) The gene's tissue specificity must be correct - it is no use inserting, for example, a pea seed protein gene into soybean to improve the seed quality, to have the gene expressed only in the leaves.
4) The production of the new gene product must not be detrimental to the normal functioning of the recipient plant.

Biotechnology should not be seen as a replacement for conventional plant breeding - they actually complement one another. Molecular biology is particularly powerful in the manipulation of small pieces of DNA that code for products with specific functions (eg the altered structure of one particular enzyme) but are not very useful for improving complex quantitative characters such as lint percentage or fibre strength. Even given this limitation the number of potential target genes and the possible benefits to agriculture are enormous.

**Figure 1**

**Relationship between Pressley and Stelometer for Fibre Strength**



# Figure2

## TECHNIQUE USED TO PRODUCE GLYPHOSATE RESISTANT TOBACCO PLANTS