

GENETIC ENGINEERING OF COTTON FOR RESISTANCE TO HERBICIDES.

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The challenge to our cotton industry posed by insect pests is well documented, but it is sometimes overlooked that for every dollar spent on insect control, a further 60-70 cents, amounting to more than \$30 million annually, is spent on the suppression of weeds. This figure, high as it is, does not include the intangible losses in production due to soil degradation, diminished moisture and nutrition available for the crop, and increased disease incidence, and the costs of reduced fibre quality and seasonal rotation with lower profit crops.

As cotton is naturally sensitive to a range of herbicides used for the control of broadleaf weeds, post-emergence suppression of such weeds is limited to relatively inefficient lay-by herbicides and mechanical means including inter-row cultivation and hand chipping. Cotton cannot be treated with over-the-top applications of effective broadleaf herbicides such as Roundup and 2,4-D, and is, in fact, often adversely affected by the drift of 2,4-D sprayed on grain crops in nearby fields. The introduction of genes for herbicide resistance by genetic engineering of cotton may not only provide resistance to this drift damage, but could also make possible the direct application of previously toxic herbicides to the cotton crop, thereby increasing the options for weed control.

Genetic engineering technology provides the means of transferring new qualities into cotton plants which cannot be introduced by conventional plant breeding. It is based on the premise that the genetic material (DNA) of all organisms is essentially the same and can therefore be transferred between

species. Hence, with the appropriate skills, genes for herbicide, insect or disease resistance, derived from other plant species or even such diverse organisms as bacteria, can be transferred into cotton plants, where they endow these qualities on their new host.

As an initial step in the process of developing herbicide resistant cotton, we have been working with a gene which encodes the detoxification of the herbicide 2,4-D. This gene belongs to the bacterium *Alcaligenes eutrophus*, an organism which lives in soils that have been treated with 2,4-D, and enables the bacterium to degrade the herbicide to supply its nutritional needs. The first product of this degradation process is up to one hundred times less toxic to plants than 2,4-D, and we believed that if this gene could be engineered to work in plants, then such plants would be resistant to the herbicide. The gene was therefore isolated from the bacteria, modified so that it would be recognised as a "plant" gene, and introduced into tobacco plants, which are often used in genetic engineering experiments because of their ease of manipulation. As predicted, transgenic tobacco plants carrying this gene were unaffected when sprayed with levels of 2,4-D which killed normal tobacco plants and many types of broadleaf weeds.

A gene construct similar to that used in tobacco has now been introduced into Australian (Siokra) and American (Coker) cotton cultivars. The latter has proved to be more readily manipulated than Siokra, and we now have several transformed Coker cotton plants carrying the 2,4-D resistance gene. These plants will be tested for increased tolerance to the herbicide in the near future. We are currently attempting to regenerate plants from transformed Siokra cotton tissue, an aim that we hope to achieve shortly.

Resistance genes for several herbicides, including Roundup (glyphosate) and

Glean (sulphonylureas), have been identified by other researchers, and once a reliable protocol for the transformation and regeneration of Australian cotton cultivars has been developed, these genes could be introduced as part of a comprehensive crop management program. Alternatively, such genes could be introduced into Australian varieties by cross-breeding with transgenic plants under licence, as is intended for the BT insect resistance gene (see Llewellyn *et al.* in these proceedings). Genetic engineering also offers the possibility to 'tailor-make' plants resistant to new 'designer' herbicides that possess high unit activity, low toxicity, low soil migration and rapid biodegradation, thereby providing more effective and environmentally acceptable weed control.

Several biotechnology companies in the USA are currently working towards the production of transgenic cotton plants carrying genes for herbicide resistance. Monsanto, Dupont and Calgene have developed plants resistant to Roundup, Glean and Bromoxynil, respectively, and are at the various stages of crossing these genes to elite varieties, bulking seed and conducting field trials of the transgenic plants. Although in their infancy, the technologies that we are developing at the CSIRO Division of Plant Industry will ensure that the competitive advantage resulting from transgenic herbicide resistant cotton will be readily available to the Australian cotton grower.

