Can genetic engineering help?

I R. Barclay

Follow this and additional works at: https://researchlibrary.agric.wa.gov.au/journal_agriculture4

Recommended Citation
Available at: https://researchlibrary.agric.wa.gov.au/journal_agriculture4/vol22/iss4/6
IMPORTANT DISCLAIMER

This document has been obtained from DAFWA’s research library website (researchlibrary.agric.wa.gov.au) which hosts DAFWA’s archival research publications. Although reasonable care was taken to make the information in the document accurate at the time it was first published, DAFWA does not make any representations or warranties about its accuracy, reliability, currency, completeness or suitability for any particular purpose. It may be out of date, inaccurate or misleading or conflict with current laws, polices or practices. DAFWA has not reviewed or revised the information before making the document available from its research library website. Before using the information, you should carefully evaluate its accuracy, currency, completeness and relevance for your purposes. We recommend you also search for more recent information on DAFWA’s research library website, DAFWA’s main website (https://www.agric.wa.gov.au) and other appropriate websites and sources.

Information in, or referred to in, documents on DAFWA’s research library website is not tailored to the circumstances of individual farms, people or businesses, and does not constitute legal, business, scientific, agricultural or farm management advice. We recommend before making any significant decisions, you obtain advice from appropriate professionals who have taken into account your individual circumstances and objectives.

The Chief Executive Officer of the Department of Agriculture and Food and the State of Western Australia and their employees and agents (collectively and individually referred to below as DAFWA) accept no liability whatsoever, by reason of negligence or otherwise, arising from any use or release of information in, or referred to in, this document, or any error, inaccuracy or omission in the information.
Can genetic engineering help?

Plant breeders aim to improve today's crop varieties by bringing genes—inheritance particles—from different varieties into new, more-desirable combinations. This is a lengthy process, and in some cases the prospects of success may be limited by the lack of suitable genes in any variety of the crop being bred.

However, it may be possible to reduce the time involved and extend the genetic variability available to the breeder by developing such techniques as haploidy and genetic engineering.

Department of Agriculture plant breeder Dr Iain Barclay is studying both avenues.

Conventional techniques

Most primary producers are aware that many years elapse between the time plant breeders set their objectives and the release of new commercial plant varieties.

In the case of cereal crop varieties, for example, it is a 12 year programme at least.

The sequence starts with cross breeding, the conventional source of genetic variability. Crossing and growing the first generation hybrids (F1s) in glasshouses, is a year's work. In the next generation (F2), which comprises the products of 'selfing' the crossbreds, the different genetic characters start to segregate. This segregation continues in succeeding generations but to a decreasing extent. This means that pure varieties cannot be established in early generations because any plant selected will continue to produce many different types in the next generation.

A typical breeding programme may use these early generations to select superior plants from which uniform lines can be selected later.

The F2 plants are grown in the field and desirable plants are selected. In the next year the third generation (F3) seed from the selected plants are planted in rows for selection on agronomic characters such as straw height and strength, disease resistance, and time to maturity. Then selected lines are sown in yield trials for two years. Preliminary quality tests also are carried out in these early stages, to help screen out undesirable lines.

At the end of this phase of testing, there will have been enough generations of inbreeding to allow individual true-breeding plants to be selected. Seeds from selected plants are grown in rows for yet another year for seed increase, followed by two more years in yield trials with convenient quality testing.

At this point the surviving lines must undergo three years of rigorous variety trials at many locations in competition with standard varieties, and undergo further quality testing. Those which pass through this stage next come under the scrutiny of the various grain advisory committees before being recommended to producers.

Thus any new technique which might shorten this span of years would be welcome.

Haploidy

Let us imagine that at the first generation F1 stage the breeders could interrupt the sequence by getting pure lines immediately. They would then save at least three years in the breeding programme.

There are prospects of doing this by separating and growing certain cells of F1 crossbreds before they enter the fertilisation phase. In most species normal cells contain two sets of chromosomes (the thin thread-like structures which carry the inheritance particles—genes). Egg and pollen grain cells each contain only one set of chromosomes. During fertilisation the chromosomes from the egg and pollen are combined in the one cell which then develops to form a new plant.

Dr I. Barclay selects anthers ... pollen-producing bodies ... for haploidy studies.
A mature, unfertilised barley egg cell. Left are the synergid cells, through which the pollen tube enters during fertilisation. Right are the polar nuclei which, after fertilisation, develop into the endosperm or starchy part of the seed.

Plant breeders around the world are exploring the possibility of using ‘anther culture’ techniques to produce haploid plants—plants with just one set of chromosomes. This involves taking immature anthers (pollen-producing floral parts) and culturing them on a growth medium. The object is to try to induce the young pollen grains to alter their normal development and produce seedlings instead of mature pollen grains. These seedlings will develop into haploid plants with only one set of chromosomes.

To produce normal fertile plants these haploids must be treated, usually with the drug colchicine, to double the chromosome number back to normal. This new set of chromosomes will be an exact copy of the set originally in the haploid and hence the genes on each set of chromosomes will be the same. The plants produced as a result will be pure bred.

Unfortunately the techniques for, and success rate of, inducing pollen grains to form plants directly, vary for different species. For cereals, success has been very limited, often with less than one haploid plant being produced per thousand anthers cultured.

However, alternative methods may be available. It has been found that a wild relative of barley, *Hordeum bulbosum*, can be crossed with cultivated barley. The young hybrid embryos, instead of developing normally, progressively lose all of the *H. bulbosum* chromosomes, leaving the one set of barley chromosomes that were originally present in the egg cell.

Initially the success rate in getting these haploid embryos to grow into plants was low. But improvement in the techniques being used has resulted in reports of up to 30 per cent of haploid embryos developing into plants. It also has been possible to cross *H. bulbosum* with wheat to produce haploid wheat plants in the same manner. However the range of wheat varieties which will cross with *H. bulbosum* is limited. In Western Australia breeders are exploring ways of crossing *H. bulbosum* with all wheat varieties as well as developing the haploid technique for use in the Department’s barley breeding programme.

**Genetic engineering**

A major purpose of crossbreeding is to incorporate desirable genes into improved plant varieties... for example genes for disease resistance. Through ‘genetic engineering’ it may be possible to extend the range of useful genes available to the plant breeder by allowing genes to be incorporated from alien species into cultivated crops.

To be successful, genetic engineering has to be carried out on single cells. This requires a technique for cloning, that is, growing cells in culture and then being able to regenerate complete plants from these cells. In Canberra, CSIRO geneticists are developing cloning techniques and have found a surprising bonus.

It would be expected that plants regenerated from a cell culture would be genetically identical to each other and to the original parent plant. Surprisingly, sugar cane plants produced by this technique have shown a wide range of genetic diversity which can be used to select improved lines. At is stage the Western Australian Department is sending its latest wheat varieties to CSIRO for cloning to determine if similar useful variability will occur in wheat. If it does, Western Australian plant breeders will then be able to evaluate its usefulness and determine policies for the future.

Before alien genes can be introduced into crop species they must be identified and isolated. It is not an easy task to decide which gene might particular gene from the thousands of other genes present in a species. Once identified the next step is to incorporate the selected gene into a ‘vector’ which will enable the gene to be transferred to another organism. Among the vectors being studied are extra-chromosomal particles known as ‘plasmids’.

Plasmids have their own small amounts of genetic material (D.N.A.) into which the selected gene can be incorporated, using suitable enzymes. It is not an easy task to decide which gene from the thousands of other genes present in a species. Once the techniques being used has isolated the next step is to ‘vector’ which will enable the gene to be transferred to another organism. Among the vectors being studied are extra-chromosomal particles known as ‘plasmids’.

Genetic engineering is clearly a complicated technique and at present is not developed enough to be used directly in breeding programmes. Plant breeders in Western Australia will be keeping a close watch on future developments.