Biotechnology has opened unprecedented avenues for exploring biological systems. One of the key techniques in genetic engineering is gene transfer, which involves transfer of recombinant DNA into plant cells to generate transgenic plants. Genes and genomes from a wide range of organisms are being manipulated for the benefit of mankind. Application of genetic engineering in agriculture has produced significant achievements such as yield improvement of major food crops.

Introduction

Gene is the fundamental unit of heredity in any organism. Mendel first proposed this in 1865 but he called it ‘factor’. Later, in 1909 Johansson renamed ‘factor’ as gene. Gene is an active segment of DNA. The isolation and manipulation of an organism’s genome for the betterment of mankind is termed genetic engineering, a fast growing science in the field of biotechnology (Box 1). One among the products of genetic engineering is transgenics.

Simply, transgenics is transferring foreign genes from one organism to another organism of interest. The transgenic plants and animals derived thus are frequently referred to as genetically modified organisms (GMOs). The first transgenic plant was tobacco — developed in 1983. There are more than 50 other plant species where foreign genes have been transferred viz., tomato, potato, sunflower, cotton, carrot, grapes, etc. (Box 2). Initially, the production of tranagenics was restricted to dicotyledonous plants for the reasons detailed below. But, now it has been extended to several monocots like wheat, maize, rice, oats, etc.

Why Transgenics?

Classical genetics, as applied to plant breeding, cannot be separated from other improvements in agricultural production.
Box 1. Milestones in Transgenic Science

1951 First amino acid was sequenced by F Sanger and H Tuppy.
1953 JD Watson and F H C Crick proposed that DNA is a double helix.
1958 Discovery of DNA polymerase by Kornberg’s group and DNA replication studies began.
1959 Isolation of RNA polymerase.
1970 Discovery of reverse transcriptase showed that RNA can act as the template for the transcription of DNA and opened the way for cloning using cDNA libraries.
1970 General method was developed by M Mandel and A Higa for introducing DNA into cells by calcium dependent method.
1970 G H Khorana synthesised an artificial gene from DNA nucleotides.
1971 K Danna and D Nathans first used restriction endonucleases for mapping DNA.
1972 The recombinant DNA Era begins. J Mertz and R W Davis used T4 ligase to join DNA molecules.
1973 A DNA fragment containing the Kannamyin-resistance gene was cut out of plasmid using EcoR1 and ligated into the unique EcoR1 site of the plasmid pSC101 that was tetracycline resistant. Doubly resistant clones were isolated.
1973 Cohen and his co-workers invented cloning.
1975 E M Southern detected specific DNA sequences in gels.
1976 cDNA cloning of eukaryotic genes – the rabbit β-globin gene.
1977 A M Maxam, W Gilbert and Sanger and others gave the first DNA sequencing method.
1983 Ti plasmid are used as vectors for transformation of plant cells by Herrera-Estrella and co-workers.
1983 First plant species (Nicotiana) was transformed using Agrobacterium tumefaciens system by Baston and others.
1984 Biolistic process was invented by E D Wolf, N K Allen and J C Sanford.
1984 First transformation was performed in tobacco using direct gene transfer technique by Paszkowski and others.
1985 The polymerase chain reaction (PCR) technique was first used by R K Saiki, G Mullies, F Faloona and their co-workers to artificially multiply DNA sequences.

It has been estimated that genetic improvement alone accounts for 50% of the increased harvest.

Conventional breeding techniques aim to introduce genetic diversity into desired plants so as to evolve superior plants. This involves many time-tested procedures. However, evolving elite varieties takes comparatively a very long time, even up to 8 years. Further, in conventional breeding, the transfer of desirable genes from unrelated or wild relatives is limited for any of the reasons below:

- failure of pollen germination