Review

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Plant Biotechnology for Sustainable Use of Natural Resources in China

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Developing countries face big challenge in agriculture and environment protection, with their rapidly increasing population. Although traditional technologies still have potential for improving agricultural production, there are some limitations to further increasing crop yield, such as genetic barrier in remote hybridization. The achievements in plant biotechnology make it possible to fully use natural resources for increasing genetic variation, protecting biodiversity, and crop improvement, by using plant tissue and cell culture techniques, and gene transfer.

Plant tissue culture has been a very active and productive part of biotechnology in China. Plant regeneration has been achieved in meristem and callus culture in over 700 plant species so far. Micropropagation techniques have been extensively used for mass production of virus-free or clonal propagation of sugarcane, cassava, potato, *Eucalyptus*, *Populus*, and a number of horticultural plants. Micropropagation technique has also been successfully used to propagate some rare species, such as, wild *Camellia* [1] and lots of Chinese medicinal plants. Many wild plant species have been applied in tissue culture, also for transferring their stress or pest resistant character(s) and some of other unique agronomic traits to cultivated crops. For example, by embryo rescue, cotton hybrids were obtained from remote hybridization of *Gossypium hirsutum* with 14 wild species of cotton in the Institute of Genetics, CAS [2]. From those hybrids, 6 new cotton varieties with high yield and disease resistance have been released after a series of backcross and selection. China is rich in biodiversity of *Actinidia*. Among over 60 species in the genera *Actinidia*, 57 species and 39 varieties have been found in China. A new strain of kiwit fruit, "Ke Zhi No. 1", with big and green fruits, no hair, that is easily peeled, was selected out from the hybrids of *Actinidia deliciosa* (female) × *A. arguta* (male), also obtained by embryo rescue technique in the Institute of Botany, CAS.

Anther and microspore culture has been used for obtaining haploid plants, which is useful in crop breeding. So far, haploid plants have been obtained from more than 50 species in China. Some new varieties of rice, wheat, barley and rapeseed have been released in agricultural production. Through anther culture combined with remote hybridization, chromosome breakage and rearrangement may occurr, that increases the frequency of genetic exchange. Different alien substitution lines, multi-addition and translocation lines could be obtained even within one generation in wheat [3].

Plant protoplast culture and somatic hybridization have also been paied attention to. Plant regeneration from protoplast has been achieved in over 70 species in China, including lots of important crops, such as maize, wheat, sorghum, soybean, peanut, broad bean, cotton, some woody plants (*Morus alba*, *Paulownia fortunei*, *Platanus orientalis*, *Populus*, etc.) and fruit trees (*Actinidia*, *Citrus*, *Dimocarpus longan*, *Eriobotrya japonica*, *Malus pumila*, etc.) (see [4]). Somatic hybrid plants have been obtained in the first time from protoplast fusions of wheat with *Haynaldia villosa*, *Leymus chinensis*, *Agropyron elongatum* and *Psathyrostachys juncea* [5], the combinations of cultivated rice with wild species, *Oryza officinalis* [6], and *Panicum maximum* [7], and also from *Actinidia* [8], etc.

Since the first transgenic plants of tobacco and potato were obtained by *Agrobacterium*-mediated gene transfer in 1983, great progress have been made in the past 15 years, and various techniques of gene transfer have been developed. In China, over 50 species of transgenic plants have been reported so far, with more than 100 genes (including markers) used in these studies. They include cereal crops (rice, wheat, maize, sorghum), economic crops (cotton, soybean, peanut, rapeseed, etc.), vegetables (cabbage, Chinese cabbage, cauliflower, sweet pepper, tomato, etc.), woody plants (*Populus*, *Eucalyptus*, mulberry, etc.) and fruit trees (apple, *Citrus*, kiwifruit).

The main research projects on transgenic plants in China cover insect and disease resistance, stress tolerance, male sterility, nutrition improvement, and transgenic plants used as bioreactor (see [4, 9]). For example, different B.t. toxin genes and proteinase inhibitor genes cloned from arrowhead and cowpea have been used for increasing insect resistance of different crops (tobacco, rice, maize, cotton, cabbage, cauliflower, poplar tree, etc). Transfer of virus coat protein gene (cp) of TMV, CMV, PVX/PVY/PLRV, SMV, TuMV, RYSV (N gene), and BYDV increased virus resistance in the respective transgenic plants (tobacco, tomato, pepper, potato, soybean, rapeseed, rice, wheat). Virus resistant plants have also been obtained by transfer of replicase gene of TMV (tobacco), PVY (potato) and RDV (rice), and by using ribozyme strategy for CaMV (rapeseed), and RSTVd (potato). Xa 21 and Xa 7 gene have been used for increasing the resistance to rice bacterial blight. Anti-bacterial peptide genes (cecropin, Shiva, etc.) have also been used for bacterial disease resistance. D-Mannitol-1-phosphate dehydrogenase gene (*MtlD*) and D-glucitol-6-phosphate dehydrogenase gene (*GutD*) cloned from *E. coli*, and BADH gene cloned from *Atriplex* *hortensis* have been used for obtaining transgenic plants with salt tolerance. Some of transgenic plants, e.g. virus resistant potato and tomato, insect resistant cotton, rice and poplar are already in field trials. Herbicide resistant rice is being used for hybrid rice seed production. More transgenic plants will be obtained in a couple of years, that would be used not only for genetic engineering in crop improvement, but also for understanding the function of the gene concerned in fundamental researches.

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