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Author(s)	Le, Tran Binh
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BIOTECHNOLOGY TOOLS FOR ENVIRONMENT-FRIENDLY AND SUSTAINABLE DEVELOPMENT

Le Tran Binh,
Institute of Biotechnology, Hanoi

Abstract

Modern biotechnology including genomics, proteomics and bioinformatics provides powerful tools for better understanding the genetic materials, their action mechanism and their diversities in all living organisms in order to ensure sustainable development of agriculture, food processing and biopharmaceutical industries, biodiversity and environmental protection. Transgenic crops enables production with less chemicals and lower cost for better product quality, but requires accession on biosafety and environmental impact. Recombinant DNA techniques opens beneficial industries for new generation vaccines, diagnostic kits and gene and cell therapies. Environmental biotechnology includes bioremediation, biodegradation and biotransformation as well as biosensor for pollution monitoring, detection of chemical residues modernizes the environment science and industry.

Introduction

Biotechnology can be broadly defined as using living organisms or their products for commercial purposes. Presently, there has been remarkable progress in biotechnology including genetic engineering that provides a breakthrough with potential applications in the agriculture, medicine, biotechnology-based industries and environmental protection. This will certainly contribute to the improvement of the conditions of the rural communities.

The recent development in biotechnology in Vietnam has proved that agricultural biotechnology would contribute considerably to the securing and increasing a sustainable production and supply of sufficient amounts of food, feed and fiber. The current status of biotechnology development including the facilitating in genomic, proteomic and bioinformatic studies in the National Key Laboratory for Gene Technology at Institute of Biotechnology, Hanoi, has also expanded to medicinal, pharmaceutical and environmental biotechnology.

Biotechnology for sustainable agricultural production

Development of transgenic crops: Genetic engineering in crop plants is firstly started with non-food crop such as cotton, fast-growing Paulownia and Chrysanthemum. Genes for transformation partially originated from advanced laboratories via MTA and from own isolation and discoveries (Le Tran Binh 1992, 1997, 1998; Nguyen Trung Nam, 2002). Majority of genes used is target for disease and insect resistance and a biotic stress tolerance (Table 1). In collaboration with SEA countries transgenic papaya resistance to ring spot virus have been created using gene isolated from local papaya virus and constructed in suitable vector for *Agrobacterium* transformation.

Table 1: Gene collection, target crops and transformation methods for development of transgenic crops
(Le Tran Binh, 1999 and 2001)

Gene available:	
❖ Xa21	- resistance to bacterial blight
❖ CryIA(a,b,c,d)	- resistance to insects
❖ Chitinase gene	- fungi disease resistance
❖ P5CS, OAT, TPS, nhaA, HAL	- salt- & drought-tolerance
❖ CgS, SAT	- enhancing aa contents
❖ CP, replicase	- PRSV resistance
❖ ACC antisense	- delayed ripening

Crops:	
❖ Non-food crops:	cotton, Chrysanthemum, Paulownia,
❖ Food Crops:	rice, papaya, potatoes, sugarcane, tomato

Methods:	
❖	Biolistic particle delivery system
❖	via <i>Agrobacterium</i>

Successful case will be the bollwormborer resistant cotton, which helps to reduce the insecticide application from 15 to 1-2 sprays/crop and to lower the production cost to the competitive import price of US\$ 1/kg. The field trials will be soon performed for PRSV resistant papaya in the farmer backyards.

Problems concerning with pollen outflow will be solved by integration of genes into chloroplasts. Decreased biodiversity in modern agriculture could be prevented by international efforts on in situ preservation. And long-term environmental impacts of transgenic crops has to be considered by pre-commercial testing and well-planned field trials.

Current status of Bio-safety in Vietnam: Vietnam became a party of the Convention on Biological Diversity (CBD) since 1994 but has not yet signed the Cartagena Protocol on bio-safety. However, Vietnam recognizes the ecological and economic importance of an effective bio-safety regulation in biotechnology development. It also recognizes the need to have in place an appropriate safety regulation before large-scale field trials of GMOs are being conducted and released to the environment. At present, Vietnam is in a process of designing, developing safety regulation and has brought into the government consideration for rectification and approval of Cartagena Protocol.

Responsibility for drafting the National Regulation on Safe Management of Living Modified Organisms and their products (the Regulation) lies with the National Environment Agency (NEA) under Ministry of Resources and Environment. However, many experts from biotechnology research institutes and governmental agencies are strongly contributed and involved in drafting and incorporating the Regulation in National Laws. The draft Regulation has passed and endorsed by the Committee, which was led by the MORE and is now under consideration by the Government. So far, Vietnam has not had in place the Regulation as well as the monitoring procedures for implementing it. This is one of the reasons that delay the further GMOs product development.

Future plan: The use of transgenic plants and livestock as bioreactor for biofarming pharmaceutical proteins will be the next attempts for agricultural modernization. Degradable plastics produced from transgenic materials will also be the application of biotechnology in sustainable agriculture.

Biotechnology for conservation of biodiversity and reforestation

The use of molecular biology tools in assessment of genetic biodiversity in local rice variety collection as well as groundnut germplasms collection for identifying gene resources for aluminum toxicity, salinity, droughty and floating tolerance as well as fungi and bacterial disease resistance have been conducted by in collaboration with IRRI, Cornell University, ICRISAT ... in order to develop molecular marker for MAS and for biodiversity study.

Plant tissue culture techniques are nationally widely applied for micro propagation of forest trees such as hybrid Eucalyptus, Acacia, Paulownia, edible bamboos, ... for reforestation million ha deforested areas (Table 2).

Table 2: Activities of plant tissue culture laboratories in the provinces to support the National Reforestation Program

Investment:

- ❖ Number of national and provincial laboratories for plant tissue culture: 51
- ❖ Investment: DVN Million 600 – 1000 (US\$T ~40 – 60)
- ❖ 6-10 permanent staff

Plants propagated:

- ❖ Food crops: Potatoes, Taro, Sweet potatoes
- ❖ Fruit crops: Pine apple, Banana
- ❖ Industrial Crops: Sugar cane, Coffee, Agaves
- ❖ Forest trees: Eucalyptus, Acacia, Paulownia, Bamboo
- ❖ Flowers: Orchids, Chrysanthemum, Carnation, Rose

Status: Technology well adapted and ready for transfer into large-scale production, still lacking of production contracts

Environmental biotechnology

Environmental Biotechnology can be broadly defined as using living organisms or their products to address the human impact on the environment for commercial purposes. Two major components of environmental biotechnology are (i) bioremediation including phytoremediation and (ii) the development and application of "bioanalytical" techniques including immunoassays and biosensors. Bioremediation is the use of living organisms to degrade environmental pollution or to prevent pollution through waste treatment (Atlas, 1995) or the application of biological treatment to the cleanup of hazardous chemicals (Cookson, 1995.). Technologies for bioremediation treatment are biostimulation, bioaugmentation, landfarming, composting, bioreactors, bioventing and biofilters. The most important action in bioremediation is the microbial degradation.

Microbial degradation is regarded as the catabolism of a compound into molecules that can enter intermediary or central metabolism by microbial organisms and practically could be applied in two technical options:

(i) **Enrichment technique** is applied to promote growth of desired microbial strains needed for biodegradation polluted compound. If failure to successfully isolate an organism(s) capable of growth does not necessarily mean that the compound is resistant to degradation; Misuse or technique errors may be the reason e.g. too high or too low a substrate. If nothing is detected and the compound routinely persists in natural, it may be concluded that the compound will not serve as the sole carbon & energy source. Limitations of enrichment are: Culturable bacteria represent only 0.1% to 5% of the total bacteria (Staley and Knopka, 1985). Enrichment limits the number and relative growth rates of organisms obtained from the environment (Harder and Dijkhuizen, 1982).

(ii) **Impact of a microbial "population"** will be applied for concerting efforts by many organisms in mineralization. Microbial communities can use as sole sources of carbon and energy compounds that cannot be degraded by any single organism alone. For examples: (a) dioxin like compounds could only be degraded by several microbial strains (Schauer et al. 2000, Dang Cam Ha et al. (personal communication); (b) Parathion to 4-nitrophenol and diethyl phosphate with *Pseudomonas stutzeri* and *P. aeruginosa* then grows on the 4-nitrophenol (Daughton and Hsieh, 1977). (c) DDT is converted by cometabolism to 4-chlorophenyl acetic acid *Pseudomonas* and the product is then used by *Arthrobacter* (Pfaender and Alexander, 1972)

Technologies using microorganism for detoxification of heavy toxic metals by microbials to non-toxic oxidative forms have been applied to treat wastewater in the metal-processing handicap settlements in Nam Dinh province (Lai Thuy Hien and Le Thi Lai, 2002).

Gene technology in environmental sciences: Heavy metals could be uptaken by various plant species. Improvement of the plant using genes encoding metal binding protein will be an effective remediation of the polluted soil (). Plastic linking molecules from petroleum products of petro-chemical factories bonds are so strong, the plastic does not disintegrate, so around 20% (vol) landfills are plastic. Biodegradable plastic produced by *Alcaligenes eutrophus* in C rich medium. The excess C is stored by the cells as granules of polyhydroxybutyrate (PHB). Biodegradable plastic in soil will be released as carbon dioxide and water. PHB plastic bag: disappears in 6 weeks shampoo bottle: gone in 6 months. Transformation of the bacterial genes into plants creates PHB producing plants as a factory. The benefits are using plants as renewable plastic source instead of oil, these plants are new cash crops for the farmer and their production is environmentally safe and cheap (Sommer, 1992).

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