Biotechnology in Agriculture: Current Status

by

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Genetic transformation is a very powerful tool for crop improvement. In some dicot species, agronomically and economically useful traits such as herbicide resistance, insect resistance, virus resistance and male sterility have been introduced by the transformation method. For example, a rose that contains genes from petunia controls the synthesis of blue floral pigments. Potato that contains bacterial genes can make polymers that can be used to make biodegradable plastics. The luciferase gene that cause fire flies to glow, then the transfer of luciferase gene and all the other genes linked to it is successful. Conversely, tomatoes are genetically engineered when the tomato gene for the specific carbohydrate-degrading enzyme is altered in the laboratory and reinserted in the tomato plant. The vine-ripened fruits from these plants have all the natural flavors, and stay firm during shipping and storage (Moore et al, 1995). Other examples of genes that have been used for plant improvement are the peas seed storage protein (Higgins et al, 1988), pea is rich amino acid albumin 1 (Dart, 1993), the rice chitinase gene for fungal disease resistance (Li et al. 1995), and the cowpea trypsin-inhibitor gene CP-1 for insect resistance (Hilder et al, 1987).

Several bacterium species served as gene sources for resistance. These include *Salmonella typhinurium* for glyphosate resistance (Comai and Stalker, 1986; Fillati et al, 1987). *Streptomyces hygrospicus* for Basta resistance (Block et al, 1987) and *Bacillus thuringensis* for insect resistance (Burgess, 1986). To increase virus tolerance to plants, coat proteins of virus have been introgressed to the plants. Examples are the alfalfa mosaic virus coat protein introduced into tobacco for AMV resistance (Turner et al, 1987), and the potato virus x coat protein introduced into potato for PVX resistance (Hoekema et al, 1989).

A locus for resistance to bacteria leaf blight was transferred from the wild species of *Oryzae longistaminata* to cultivated rice line IR24 through repeated crossing and repeated back crossing in the early 80's. The locus is called *Xa21* gene. It was found to confer resistance to all known *Xanthomonas oryzae* pv *oryzae* race in the Philippines. Compared to other plant resistant genes, the structure of *Xa*21 encodes a receptor kinase-like protein carrying leucine rich repeats (LRRs) in the putative extra cellular domain, a single pass transmembrane and serine threonine kinase intracellular domain (Wang et al, (1996). The sequence of the predicted protein suggests a role in cell surface recognition of a pathogen ligand and subsequent activation of an intracellular defense response. Receptor protein kinases mediate cellular signaling processes in diverse biological systems. One possible role for these proteins in plants is in mediating disease resistance. Cellular signaling processes appear to be of central importance to the mechanism by which plants resist viral, bacterial and fungal pathogens (Wang et al, 1995).

Weeds compete with crops for soil nutrients. This routinely leads to significant losses in yield. Modern agriculture makes use of herbicides to control weeds and minimize the losses. Unfortunately, the available herbicides seldom provide the degree of specificity that is desired, and most herbicides control only certain classes of weeds and not all. Broad-spectrum herbicides may give good weed control, but, in so doing, usually have deleterious effects on the growth of the crop plant as well. As a result, scientists are now evaluating approaches to weed control. The most promising is the development of herbicide-tolerant plant varieties for use with broad spectrum or totally non-specific herbicides. Glyphosate is one of the most potent broad-spectrum herbicides known and marketed under the trade name *Round up*. Glyphosate acts by inhibiting the enzyme 5-enolpyruvylshikimate – 3-phosphate synthase (ESP synthase), an essential enzyme in the biosynthesis of aromatic amino acid tyrosine, phenylalanine, and tryptophan. These aromatic amino acids are essential components in the diets of higher animals since the enzymes that catalyze the biosynthesis of these amino acids are not present in higher animals. Therefore, since higher animals contain no ESP synthase, glyphosate has no toxic effect on animal systems. In this respect, glyphosate is an ideal herbicide. Glyphosate-tolerant plants have been produced using an ESP synthase cDNA isolated from a glyphosate tolerant petunia cell culture line. The glyphosate-tolerant cell line was isolated by selecting for gradually increasing resistance to glyphosate. The resulting transgenic plants were tolerant to four times the concentration of glyphosate required to kill control plants (Gardner, et al. 1991).

The gene from *Bacillus thuringensis* that produces proteins toxic to particular insects has been successfully transferred to plants. The toxins accumulate as crystals inside the bacteria during sporulation. Upon ingestion by susceptible insects, they are processed to an active form and kill the insects by interfering with ion transport in the midgut. The toxins are believed to be biodegradable and inactive against mammals and other animals. Genes for several of these toxins, active against different insects have been cloned, sequenced and expressed in foreign hosts. The selectivity of the toxin can be demonstrated by feeding experiments. Whereas 10^4 spores of *B. thuringiensis* (San Diego strain) per cm^2 of leaf killed 90 percent of adult and larval forms of elm beetle, 10^6 spores per cm^2 of leaf of the Lepidoptera specific *B. thuringensis* (HD-1 strain killed only 5 percent of elm beetle (Grierson and Convey, 1988).

Other traits already commercialized in field trials include herbicide tolerance, hybrid technology (genes for male sterility), hybrid technology and herbicide tolerance, and high lauric acid in canola. In corn, control of corn borer, herbicide tolerance, insect protected/herbicide tolerance, hybrid technology, and hybrid technology / herbicide tolerance were listed. Cotton, on the other hand, includes bollworm control with single genes, herbicide resistance and insect protected / herbicide tolerance. Potato has resistance to colorado beetle while soybean has herbicide tolerance and high oleic acid. For tomato, its trait is its delayed but improved ripening while it is virus resistance for vegetables and fruits. In rice, the traits that are already in field trials / development include resistance to bacterial blight, rice borers, storage pests, and fungal disease, improved hybrid technology; and herbicide tolerance.