Update on Plant Biotechnology

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Previously, I have discussed with you various achievements in crop improvement using plant biotechnology (test-tube cloning; genetic engineering). Initially, we were talking just about 'blue sky' type of research which had great potential, but admittedly was not near commercialization. During the last few years, this situation had changed dramatically; today there are literally millions of acres planted to crops containing genes new to crops or using products obtained through biotechnology.

What I want to do here is to provide a very brief update on where and how plant biotechnology is being used in crop production. This overview is not intended to be exhaustive, but merely to provide a benchmark of progress.

There are roughly three major areas where plant biotechnology is being used in significant commercial settings:

1. GENOMICS
   - WHAT GENES DOES AN ORGANISM CONTAIN?
2. NEW PLANTS
   - RESISTANCE, TOLERANCE, QUALITY
3. NEW 'CHEMICAL' CONTROL AGENTS
   - BIOPESTICIDES

Plant genomics involves deciphering the genes and genetic relationships in crop plants. For example, there are major efforts underway to identify ALL the genes in some of our major crop species. In addition, such work has progressed well in cranberry with the published research from Nick Vorsa's laboratory in New Jersey.

The genetic improvement of our crop plants themselves is probably the most active area of plant biotechnology. As can be seen in Table 1, the majority of the work involves agronomic crops and either pest resistance using the B.t. genes or tolerance to broad-spectrum herbicides. However, there is also considerable work on using biotechnology to make plants produce economical products that they previously could not naturally synthesize. Most of these activities involve pharmaceuticals (Table 2) and are collectively being called 'pharming'.

In addition to using biotechnology to directly improve the crops we grow, various products used in crop production have been created using biotechnology. These primarily involve 'biopesticides' and 'biofungicides' (Table 3).

All this activity in introducing new crops and products has also been accompanied by considerable corporate restructuring. In most cases, such restructuring has involved extensive consolidation of companies to form large and multi-faceted conglomerates. A good example is Monsanto which has incorporated a large number of companies, some of which are listed in Table 4. These large conglomerates usually contain not only a unit that produces and markets select chemicals such as herbicides, but also seed companies

(breeding, seed marketing), biotechnology research and development units, and a pharmaceutical arm.

One complication that has rapidly arisen in crop biotechnology and is a major limitation to the full use of this revolutionary tool is disputes over ownership of genes and molecular methodologies. For example, the use of B.t. genes is complicated by a multitude of patent infringement lawsuits between Mycogen, Monsanto, DeKalb Genetics, CIBA-Geigy, Pioneer Hi-Bred, and Plant Genetic Systems, among others. Unfortunately, such turmoil and uncertainty as to who-owns-what creates major problems when a smaller group, such as cranberry growers, wish to access the technology.

One previous complication, that of securing approvals to commercialize the genetically engineered crop, has been much reduced in importance, at least in the U.S. and Canada. Major problems with government approvals can be expected to arise, however, if the crop cannot pass a number of assessment criteria (Table 5).

In summary, the commercialization of crop biotechnology is certainly well along and very active. For example, in 1997 alone, more than 20 million acres of U.S. farm land were planted to crops engineered with the B.t. gene. Biotechnology is being utilized more and more routinely in normal, everyday plant breeding activities, but more and more the fruits of this labor are being sequestered by large, multi-faceted companies.

Table 1. Examples of crops that are presently being grown commercially and have been modified using biotechnology.

COMPANY	CROPS	NEW TRAITS
MONSANTO ('ROUND-UP READY')	CORN POTATO SOYBEAN	HERBICIDE TOLERANCE PEST RESISTANCE (Bt)
CALGENE ('BXN')	COTTON	PEST RESISTANCE (Bt) OIL QUALITY (SOAPS, DETERGENTS)
AGRAEVO ('LIBERTY LINK')	CORN CANOLA	HERBICIDE TOLERANCE
DEKALB GENETICS ('DEKALBt')	CORN	PEST RESISTANCE HERBICIDE TOLERANCE
DNAP ('FRESHWORLD')	TOMATO CARROT PEPPERS	LONG SHELF LIFE SWEETNESS
DUPONT ('OPTIMUM')	SOYBEANS	NUTRITIONAL OIL QUALITY
GARST SEEDS	CORN	HIGH pH TOLERANCE DISEASE RESISTANCE
NOVARTIS ('MAXIMIZER')	CORN	PEST RESISTANCE (Bt)
PIONEER HI-BRED ('IMI')	CORN CANOLA	HERBICIDE TOLERANCE
SEMINIS SEEDS ('FREEDOM II')	SQUASH	VIRUS RESISTANCE

Table 2. Some examples of advanced research that uses plant biotechnology to engineer plants to produce high valued pharmaceuticals (‘molecular pharming’).

- EDIBLE VACCINES
  - PROTEIN PRODUCED IN EDIBLE PLANT PARTS INDUCES IMMUNITY
    - BANANA
  - BEST WITH DISEASES THAT ATTACK MEMBRANES
    - DIARRHEA
- AUTOIMMUNE DISEASES
  - MULTIPLE SCLEROSIS
- PLANTIBODIES
  - PLANT PRODUCES MONOCLONAL (VERY PURE) ANTIBODIES
  - Example: TOOTH DECAY
    - *STREPTOCOCCUS MUTANS*
    - PREVENT COLONIZATION IN MOUTH BY EATING PLANT CONTAINING A ‘PLANTIBODY’ FOR THIS ORGANISM

Table 3. Biopesticide products that have involved biotechnology in their production.

COMPANY	PRODUCT	ACTION
AGRAQUEST	LAGINEX	MOSQUITO CONTROL
ECOGEN	ASPIRE, AQ- 10 CONDOR/CUTLASS	PEST, DISEASE CONTROL ON VEGETABLES, FRUITS
MYCOGEN	MATTCH, MVPII, M-PERIL, M-PEDE,	PEST, DISEASE CONTOL ON VARIOUS CROPS

Table 4. The formation of a large and very diverse biotechnological conglomerate under the parent firm Monsanto.

MONSANTO =

- CALGENE
- DOW ELANCO/MYCOGEN
- AGRACETUS
- ECOGEN
- DEKALB GENETICS
- HOLDEN SEEDS
- CORN STATES INTERNATIONAL
- ASGROW
- MONSOY (Brazil)
- ++++++++++

Table 5. Some critical assessment criteria used to evaluate whether the commercial introduction of a genetically engineered crop will create an environmental or ecological hazard.

<u>WHAT IS THE POTENTIAL:</u>

- TO BECOME A WEED
  - IMPACT NATURAL HABITATS?
- FOR GENES TO MOVE TO WILD
- TO PRODUCE A TOXIN/ALLERGIN
- IMPACT ON NON-TARGET ORGANISMS
- IMPACT ON BIODIVERSITY