

Agricultural Biotechnology in Canada: From Lab to Commercialization

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Canadian Agriculture

I thought it appropriate to give you a perspective on Canadian agriculture and the research base from a geographic perspective. Canada is made up of many different regions geographically and climatically.

There are five main types of agriculture in Canada:

Livestock - specialized in beef, swine, poultry and dairy.

Game farming - Deer, Elk, Bison, Emu and Ostrich.

Grain and Oilseeds - wheat, barley, oats, canola, corn, and soybean

Pulse Crops - peas, lentils, mustards, sunflower, dry beans.

Special Crops - potatoes, tobacco, ginseng, vegetables and fruit, forestry.

Mixed Farms - produce grains and livestock.

Each of these farm types creates a broad range of diversity from large feed lots to rangeland in cattle to intensive crop production. Of course once you have this type of agriculture it leads to extensive value adding of the industry through food processing, slaughter facilities, and other activities.

Of course having this broad agricultural base and being a major exporter of agricultural production does not just happen. It takes a major effort on the part of our research and education communities to ensure we stay on the leading edge of the science.

Biotechnology: A brief overview

Before providing detail on the agricultural sector I thought you might be interested in a brief overview of Canadian biotechnology.

Biotechnology has been used in science for several decades. However, scientists took biotechnology a great leap forward with the discovery of recombinant DNA techniques in the 1970's. Since then the term "biotechnology" has been attached to a variety of techniques, based on molecular genetics for

rapidly and precisely changing the genetic make-up of organisms ("genetic engineering").

Biotechnology, old and new is used in established industries and in those created in the last quarter of the 20th century. In Canada, applications of biotech are being pursued in four main areas.

Health Care

Aquaculture/Marine

Industrial Processes

Agriculture/Forestry

These four areas are all being actively pursued in Canadian research facilities. The following provides some indication of activities being developed in these areas.

Health Care

- Pharmaceuticals
 - Vaccine
 - Therapeutic drugs
 - Drug delivery: liposomes, transdermal systems, delayed release.
- Diagnostics
 - Agents to improve diagnostic imaging
 - Monoclonal antibody - based test for rapid identification
 - Medical tests using techniques such as genetic probes.
 - Medical devices for use in Diagnostics and surgery.
 - Cell and gene therapies
 - Laboratory Instrumentation - New Tools of Support

Aquaculture/Marine

- Improved Production Practices - Industry Health
- Growth Promoting Research
- Marine Biotech: Novel Pharmaceuticals and Chemicals

Industrial Processes

- Mineral Recovery
- Waste stream reduction
- Energy production
- Organic chemicals production
- Bio-re-mediation (Environmental Clean-up)
- Diagnostics

Agriculture/Forestry

- New plant varieties - improved quality, herbicide tolerant, etc.
- Plant disease diagnostics
- Safer post controls, such as bio pesticides and pathogen resistant crops.
- Development of improved crop production, such as biofertilizers.
- Improved insect, disease and stress tolerance in plants
- Plants and animals as factories to produce pharmaceuticals, chemicals, nutraceuticals and energy.
- Veterinary disease diagnostics, therapeutics and vaccines.
- Improved and better managed livestock and poultry for food production.
- Food processing improvements, such as enhanced cultures and contaminate detection systems.
- Non-food user for crops - cosmetics: industrial oils: fiber board, etc.

Biotechnology is continually expanding in new technical and scientific directions. Therefore, we can expect exciting new developments in bio-electronics, drug delivery, bio-remediation, and protein engineering over the next few years. Throughout the twenty-first century we will see a continuation of unanticipated scientific discoveries and yet undeveloped technologies that will accelerate Canada's biotechnology growth.

Based on this impressive list of applications for biotechnology, some would wonder what the issues or concerns are with the public. We will discuss agricultural biotechnology and the agri-food sector during the rest of this paper.

The Agriculture and Agri-Food Sector

Agricultural biotechnology applications have been developed and we are seeing some entry into the market place, even

though it has lagged behind the medical sector. There have been some key areas to deal with such regulations and public awareness that were different for agriculture. Some sample of products introduced in Canada is:

Herbicide tolerant flax from the University of Saskatchewan: edible oil flax: herbicide tolerant Canada varieties from several companies: hybrid Canada from AgrEvo: Insect tolerant potatoes (Nature Mark): Flavr-savr tomatoes: and chymazin, an enzyme used for cheese making.

The development of Agricultural biotechnology offers the opportunity to increase crop production: lower farming costs, improve food quality and safety, and enhance environmental quality. There are concerns expressed by some, having that the negative effects of biotechnology may outweigh the potential benefits. Like any new technology there are social, economic, and political factors, which will influence the development, consumer acceptance, and producer adoption of agricultural biotechnology.

Biotechnology and change is not something new to agriculture. When we look at the history of agriculture we find it has continually been impacted by change from new technologies. For example, in the era of mechanization there was the introduction of the steam engine and then the tractor, and mechanized equipment: this was followed by the chemical era where pesticides and fertilizers were introduced, hybrid varieties of crops became standard in some areas and feed additives for livestock. These technologies and others are still being introduced, from what we today call conventional science, and will continue to impact production for the foreseeable future in many parts of the world. All of these revolutionary changes had a fundamental impact on agriculture as well as significant social and economic impacts. Biotechnology is said to be the beginning of the next revolution in agriculture.

There are many factors that will impact the adoption of biotechnology into agriculture, some of which are:

- Relative benefits and costs of the technology compared to alternative inputs:
- Producers seek ways to increase profits by:
 - reducing production costs
 - satisfying changes in consumer demand
- An expanded set of public interests
 - Some are interested in food quality and safety.
 - Environmentalists are concerned about environmental quality.
 - Concerns about the impact on rural communities
 - Public confidence in the regulatory system.

- Government programs and policies and their effect on adoption.

Economic assessments of ag-biotech reveal the type and direction of expected change and which groups (farmers, industry, consumers, regions, and countries) may be affected. A review of the studies on the economic impact of agricultural biotech provided two major conclusions:

- (a) The economic impact of agricultural biotechnology is likely to be incremental rather than dramatic.
- (b) A significant amount of the economic benefit will be broadly distributed to consumers in increase supplies, stable prices, and higher valued products.

Like any new technology, there are issues and benefits around agricultural biotechnology. Therefore, this needs to be acknowledged and addressed to make this paper complete. The issues surrounding ag-biotechnology in Canada are:

- Regulatory – Ensuring we have a scientifically sound regulatory process that meets our needs and is compatible with our major trading partners.
- Public awareness – At present this is an area that is receiving a lot of attention as products enter the market.
- Finance – this is always an issue with emerging technologies. Financial support for research and development and also for new business start-ups.
- Research support – Ensuring the infrastructure is there to support new product development.
- Intellectual property – two areas of concern are ownership and compatible systems globally for patents.
- Human resources – As the industry expands there is an increasing pressure on the educational system to meet the demand.

Some of the benefits surrounding ag-biotechnology in Canada are:

- Improved production – Better weed and pest control: improved fertility: improved stress tolerance.
- Healthier animals – Improved disease control (vaccines): improved nutrition of feed: diagnostics: better genetics.
- Improved quality – Quality is already good, but we will be able to tailor more to customers needs in the future.
- Managed exports – Guarantee quality of our exports by working with the customers to determine their needs.
- Viable agriculture industries – By the 21st century biotechnology will be a key component of all agriculture globally, therefore to be viable our industry needs to be using the products of biotechnology.

In summarizing this section on agriculture biotechnology

there is one conclusion. As a tool for agricultural science, biotechnology is here and will be used globally in this industry. Those countries that adopt the technology early will help ensure that their agricultural industry remains viable. Adoption of the technology includes the creation of a level of understanding by consumers within the country.

Initiatives on Ag-biotechnology in Canada

In Canada there are a number of initiatives that focus on agricultural bio-technology-regulations: research: public awareness: industry support. I will not provide details in this section, but give you a concept of the breath of activity. Organizations involved with awareness of biotechnology:

IBAC – Industrial Biotechnology Association of Canada

Address: Suite 420 - 130 Albert Street

OTTAWA, Ontario, K1P5G4

Phone: (613)233-5586 Fax: (613)233-7541

Contact: Joyce Groot, President

IBAC is an industry organization that deals with issues, regulations, etc. on behalf of industry.

CIB – Canadian Institute of Biotechnology

Address: Suite 420-130 Mbert Street

OTTAWA, Ontario, K1P5G4

Phone: (613)563-8849 Fax: (613)563-8850

Contact: Rick Walters, Executive Director

CIB is an institutional organization which provides its members with project support, awareness of issues, etc. on all aspects of biotechnology.

FBC – Food Biotechnology Centre

Address: 12 Memorial Crescent

GUELPH, Ontario, N1H 6B9

Phone: (519)767-2873 Fax: (519)767-2718

Contact: Diane Wetherall, Executive Director

FBC is a centre that deals specifically with public awareness of biotechnology and food.

GABA – Global Agricultural Biotechnology Association

Address: 201-407 Downey Road

SASKATOON, Saskatchewan, S7N 4L8

Phone: (306)668-6639 Fax: (306)668-5564

Contact: Bob Morgan, Chair

GABA is an international organization that uses the

Internet to communicate about ag-biotechnology and international issues.

TBI – Toronto Biotech Initiative

Address: 51 Hillside Drive
AURORA, Ontario, L4G6E1
Phone: (905)727-3492 Fax: (905)713-0768
Contact: Dr. John Clement, President

TBI is a public forum organization dealing with a broad base of awareness issues.

Bio-Atlantic Inc.

Address: P.O. Box 6000
FREDERICTON, New Brunswick
E3B 5H1
Phone: (506)453-2366 Fax: (506)453-7170
Contact: Leslie Roger (temporary)

Bio-Atlantic is just getting established and will deal with agricultural, forestry and aquaculture.

OAFT Inc. – Ontario Agri-Food Technologies

Address: 1 Stone Road West
Guelph, Ontario, N1G4Y2
Phone: (519)826-4195 Fax: (519)767-6300
Contact: Ralph Shaw (temporary)

OAFT is a new organization designed to focus on the biotech aspect of the agri-food sector with a primary focus on research and commercialization.

BCBA – British Columbia Biotechnology Association

Address: Suite 450-1122 Mainland Street
VANCOUVER, British Columbia
V6B 5L1
Phone: (604)689-5602 Fax: (604)689-4198
Contact: Theresa McCurrey

BCBA is an industry organization for British Columbia that focuses on commercial development and awareness of all aspects of biotech.

AWB – Ag-West Biotech Inc.

Address: Suite 230-111 Research Drive
SASKATOON, Saskatchewan, S7N 3R2
Phone: (306)975-1939 Fax: (306)975-1966
Contact: Peter McCanns, President

AWB mandate is to facilitate commercial development of ag-biotechnology in Saskatchewan.

Besides these organizations Canada has a strong research infrastructure that is primarily made up of Agriculture and Agri-Food Canada (AAFC): National Research Council (NRC): and several Universities across the country. AAFC has 18 centers of excellence located in various parts of Canada. NRC primarily has the Plant Biotechnology Institute (PBI) in Saskatchewan that focuses on agriculture, Two of the key agricultural Universities are the University of Guelph in Ontario and the University of Saskatchewan.

Saskatchewan's Ag-biotech Initiative

The Saskatchewan ag-biotech community is the best established in Canada and is an example of where working together can create dividends. The community has a very strong research bases that is made up of a broad base of independent institutions. That combined with Innovation Place, a research park centered in the research community, created the catalyst for Saskatoon to become a leading centre in ag-biotechnology. The next few sections will look at the components of Saskatoon that went into creating this global centre.

Ag-West biotech Inc.

In 1989 Ag-West Biotech Inc. (AWB) was established with a mandate "to facilitate commercialization of ag-biotech for the benefit of Saskatchewan." The objectives of AWB are:

- To identify and enhance the development of emerging technology for the advantage of Saskatchewan:
- To facilitate a high level of commercialization of technology from local and foreign sources:
- To help establish commercial partnerships particularly between public and private sectors:
- To establish an international leadership position for Saskatchewan:
- To promote positive awareness of ag-biotechnology within the public forum:
- To facilitate the development of support systems for ag-biotech establishment.

Over the last eight years the ag-biotech industry has grown from a base of five companies to over thirty businesses today. The companies are a mixture of multinational and local start-up businesses, many of which are located at Innovation Place.

AWB is a facilitator which has created the interface

between industry, government and research/academic communities.

The Saskatchewan Community

The ag-biotech community has come together to create the leading ag-biotech community in Canada, and a world leader in the field. AWB was the catalyst that brought all the players together. Having the research, business and government all working together is what has made Saskatchewan recognized globally.

The Saskatchewan Community is made up of over 700 people involved in public sector research and over 400 in the private sector. The private sector is the one that is growing today. Annually, there is well over 100 million dollars spent on research related to agriculture and biotechnology in Saskatoon. Working together became more exemplified when the city of Saskatoon established a Regional Economic Development Authority three years ago. When they developed their business plan their two main priorities for new business was ag-biotechnology and value-added food production. In Canada, Saskatoon has been the only city with agriculture biotechnology as a priority. Others are starting to look at it.

The Farm Scene in Saskatchewan

Agriculture is a primary business in Saskatchewan. In this area we have seen major changes over the years. During this century we have seen major changes in mechanization and chemical use, with biotechnology leading the charge as we approach the next century. Farm sizes are growing, diversification is critical, and new technology is important for farming today and tomorrow as the business of farming truly becomes a business.

Today, we have less than two per cent of our Canadian population on the farm. In 1950 it was more than 25 per cent. This has created larger farms, improved production and changes in technology. This trend is expected to continue for the foreseeable future. However, I expect that biotechnology will also help maintain smaller farms as well.

To ensure that Canadian Agriculture continues to be viable in a global environment, it will need to continue to adapt new technologies and to diversify. In Saskatchewan the industry is actively diversifying and value adding the agricultural sector.

Saskatchewan is the largest agricultural producer in

Canada:

Crops: Wheat, barley, canola, oats, lentils, mustard, peas, fruits and vegetables, others.

Animals: Beef cattle, chickens, swine, bison, elk, deer, and wild boar.

Because of this large production we have a very strong research community in the province. This research is focused on improved production, value-added processing and new technologies. Linked with this production is the fact that Saskatchewan is a major exporter of agricultural products, therefore, we are constantly looking for opportunities to diversify and value-add to meet the needs of existing and new clients. To accomplish this we work in partnership with the client to ensure we are doing things right to meet their needs.

Our Business - Agriculture

To ensure our future we need to know our business, but support for the business is just as critical. In Saskatchewan our business is agriculture, and therefore, the decision to get involved in the agricultural aspects of biotechnology made sense. In a province with one million people and sixty million acres of agricultural land, it certainly is sensible to focus on agriculture.

In ag-biotech we have developed a direction, and have worked together to create a competitive position. The effort has made Saskatchewan the leading province in ag-biotech in Canada, and gives us global recognition.

Some activities that have helped maintain that leadership position through team efforts are:

- Bio-products Centre – bio-pesticides and bio-herbicides are the primary targets for this centre. The benefit is that centre members are industry researchers at universities and federal labs, working together to facilitate the commercialization of technologies.
- Canadian value-added Cereal Consortium – This centre is intended to focus on cereal technology.
- Nutraceutical Centre – This is a centre still in its planning stage, but will focus on the concept of Nutraceutical.
- GABA – global Agricultural Biotech Association – A global initiative designed to provide information on ag-biotech issues and global bases.
- The agricultural biotechnology International Conference '98.
- The first conference was held in 1996 with representation

from 24 countries and 700 attendees.

- Other activities managed by AWB.
- Networking, bulletin, workshops, trade, and seminars.

The key to all of these activities is the establishment of a sense of "working together" team (team effort).

Keys to Success

The success of the Saskatchewan biotech community has been attributed to three things:

- Flexibility,
- Knowing your business,
- Knowing your customer.

I believe that these three keys have been critical in our success in creating a viable agricultural biotech industry in Saskatchewan. If you combine those with the eight qualities identified in the book, "In Search of Excellence", by Tom Peters, you will end up with a competitive position in the global market place.

The eight qualities identified are:

- (a) A bias for action: Excellent companies do not spend years planning new strategies. They are devotees of the "do it, try it, fix it" approach.
- (b) Close to the customer: Excellent companies stay in touch with their customers and learn from them.
- (c) Autonomy and leadership: Excellent companies foster leaders and innovators throughout the organization.
- (d) Productivity through people: Top firms treat the rank and file as the root of quality and productivity gains.
- (e) Hands on, value-driven: The most successful firms are driven by sense of values the insist employees share.
- (f) Stick to the knitting: All the excellent firms analyzed restricted themselves to fields they knew well.
- (g) Simple form, lean staff: Most of the excellent companies, although big, have simple forms with minimal layers of bureaucracy.
- (h) Simultaneous loose-tight properties: Excellent companies know when to centralize and when to discourage conformity.

Opportunities in Canada: Ag-biotechnology

Ag-biotech in Canada is focused primarily in seven areas from a commercialization perspective:

- Animal Production – including health and quality
- Crop Production – yield enhancement, quality

improvements

- Microbial production – bio – fertilizers, bio-pesticides, etc.
- Value-added processing
- Ornamentals – tissue culture/micropropagation
- Environment
- Feed Biotechnology

International opportunities from my perspective area two-way street-possibilities for both countries to have win-win situations. With respect to other countries, I believe there are a number of potential areas of compatibility for collaboration.

These are in the following:

- Education – training at Canadian agricultural college:
- Research Institutes – collaboration between the two countries:
- Business Opportunities
 - animal vaccines
 - swine production
 - ornamental/seed business
 - value-added foods
 - animal feed
 - environmental opportunities on farms.

This is not meant to be an exhaustive nor specific list of opportunities. However, it is a list where specific opportunities should exist.

SUMMARY

Twenty six per cent of Canada's core biotech companies are Ag-biotechnology, compared with five per cent in the United States. Activities include the use of microorganisms, plant cells to create commercially viable products, and transformation of plants to improve specific qualities. Goals are to increase the world's food supply, enable crops and animals to resist pests and diseases, increase the nutritional content of food, and improve production efficiency.

I believe that there are business opportunities in the agriculture sector for Canada and other countries such as Korea to collaborate. These are research to research: institute to institute: business to business: and combinations of these areas.

However, for these opportunities to become a reality we need to increase our awareness of each other's activities and needs. My presentation today was not designed with specifics, but to encourage some strategic thinking by both countries on how we can do business together in agriculture and

biotechnology.

Ernst and Young's Fourth Report in Canadian Biotech Industry: Canadian Biotech '97 – Coming of Age

Ag-Bio in Saskatchewan: From DNA to the Dinner-plate.

Saskatchewan is one of the world's key ag-bio players. These are some of the factors that put it ahead:

Focus

Saskatchewan is one of the world's largest producers of agricultural products and has access to leading-edge research and development in the ag-bio field.

Leadership

Roy Romanow, Premier of Saskatchewan, is strongly supportive of ag-bio. The provincial government has provided infrastructure. Ag-West Biotech Inc., formed in 1989 with the support of the provincial government, acted as a catalyst for teams of stakeholders in community. There has been consistent focus on biotechnology from the federal and provincial governments, which the biotech community has succeeded in leveraging. In 1994, Saskatoon established the Economic Development Authority, whose first two priorities for economic growth were ag-bio and value-added agriculture.

Infrastructure

The University of Saskatchewan provides a very strong and supportive environment, through the College of Agriculture and the Western College of Veterinarian Medicine as well as its involvement in life sciences. The Plant Biotechnology Institute of NRC, VIDO, Agriculture Canada, POS, SRC, and several other institutes and organizations enhance the infrastructure. Innovation Place, the Research Park, is a big component of the infrastructure, providing facilities and services for the growing business community in ag-bio.

Financing

Large global corporations invest in Saskatchewan because there is a global market for its products. Saskatchewan benefits from several Venture funds, including the Agri-Food Equity Fund, and also from Ag-West Biotech Inc. Two major banks – Royal Bank and CIBC – have established special financing arrangements for biotech in Saskatoon, while other initiatives are available through the Western

Diversification Program (federal) and Saskatchewan Agriculture and Food (Provincial).

Technology Transfer

The University of Saskatchewan has enabled an encourage technology transfer, and is establishing training programs that will provide scientists with the necessary business skills to prepare them for careers in ag-bio. The technology transfer effort of all the research institutes in Saskatoon is an important asset.

Integration

The research community in ag-bio is well integrated vertically, enabling efficient and coordinated research along the entire value chain. This allows the sector to go beyond selling a commodity product to being the purveyor of value-added "identity preserved" products – 'from DNA to the dinner plate'.

International Profile

Saskatoon is recognized globally as a key ag-bio centre. In 1996, it hosted the world's first international ag-bio conference, ABIC '96, with over 700 people from 24 countries attending. Nothing succeeds like success.

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