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PLANT BREEDING IN WESTERN CANADA

Agriculture, and plant breeding specifically, is being impacted by numerous forces for change. From a supply side, the advent of innovative technology and more sophisticated scientific knowledge are opening up new possibilities for plant breeders and increasing the speed at which new varieties enter the marketplace. As well, profitability, provided through Plant Breeders' Rights, invites greater participation from the private sector. On the demand side, customer requirements for products that meet end-user needs for quality, safety and other attributes are becoming more specific. The customer is increasingly demanding a system that can deliver to smaller, targeted, niche markets at the same time as it delivers high-quality bulk commodities.

These changes have brought with them many issues that the industry must address, such as the need for variety registration reform, an updated seed and grain quality assurance system, changing roles for industry and government, regulatory flexibility, and intellectual property protection. This issue of the *Bi-weekly Bulletin* highlights some of the ongoing changes affecting plant breeding.

Plant breeding, simply defined, is the development of plant lines better suited for human purposes. It is the discovery or creation of genetic variation in a plant species and the selection from within that variation of plants with desirable traits that can be inherited in a stable fashion. Plant breeders, along with pedigreed seed producers and the seed trade form the seed sector.

Plant breeders can have many educational backgrounds; however most plant breeders have either a PhD or a M.Sc. in plant breeding, plus experience. In Canada, the Canadian Seed Growers' Association provides official recognition for all plant breeders, associate plant breeders and variety maintainers.

HISTORY OF PLANT BREEDING

For several thousand years, farmers have been altering the genetic makeup of the crops they grow. Despite limited understanding of genetics or biology, these early plant breeders were highly successful at producing plants that matured more quickly and that produced larger seeds or sweeter fruit.

Modern plant breeding no longer resembles those early attempts at plant breeding, which relied heavily on outcrossing and chance mutation. The modern plant breeder is an accomplished biologist with a broad understanding of: Quantitative, Population and Molecular Genetics; Plant Physiology and Biochemistry; Plant Pathology and Entomology; Statistics and Computer Science; and Botany and Agronomy. The first scientific breakthrough was Mendel's 1856 work in which he described the laws of heredity. Other major accomplishments were the inbreeding-hybridization work in corn in the early 20th century and agricultural biotechnology in the late 20th century.

Modern plant breeding is a three-step process. First of all, traits suitable for utilization by humankind are either identified or created in the plant species. This work is referred to as germplasm research, as germplasm is the collection of genetic diversity available to the plant breeder (from all sources, including crop plants, primitive cultivars and wild and weedy relatives). In the second step, plant breeders use either traditional

breeding techniques or biotechnology to combine the identified traits into the new cultivar, also referred to as variety. Finally, if the crop kind is subject to registration, the new variety is studied to assess its performance and registration by the Canadian Food Inspection Agency (CFIA) is sought.

PLANT BREEDING INSTITUTIONS

Plant breeding activities are carried out in public institutions, including government departments and universities and, for many years, by private companies. Until recently, almost all cereal and oilseed plant breeding research in Canada took place in public institutions.

Public research is made possible through funding partners. Historically, most research funding was made available through federal and provincial governments. However, more recently, increased funding from private sources has been encouraged and obtained. Typical funding sources include producer check-off funds, where a portion of the sale of a grain or oilseed is held back to fund research,

or from other players in the value chain, including grain companies, seed companies, processors, and producer organizations.

INTELLECTUAL PROPERTY RIGHTS

The *Canadian Plant Breeders' Rights Act* (PBR Act) came into force on August 1, 1990. The *PBR Act* is administered by the Plant Breeders' Rights Office, which is part of the CFIA. The *PBR Act* allows the developers of new varieties to recover their investment in research and development by giving them control over the multiplication and

sale of the reproductive material of a new variety. The rights also include the ability to charge a royalty. In order to receive a grant of rights, varieties must be new, distinct, uniform and stable. Two notable exceptions to a holders' rights are that protected varieties may be used for breeding and developing new plant varieties, and that farmers may save and use their own seed of protected varieties without infringing on the holders' rights. This second exception is referred to as Farmers' Privilege.

Intellectual property rights and the ability to get adequate financial return

for an investment have enticed the private sector into plant breeding efforts. In Canada, the private sector's investment in research and development for plant breeding purposes nearly tripled between 1987 and 2001, from \$33.2 million (M) in 1987 to \$92.5M in 2001. The public sector has benefited from intellectual property rights, as universities and government departments receive royalties for their efforts as well.

With private firm involvement, the rate at which new varieties are introduced has increased substantially. In the 1970s and

RESEARCH HIGHLIGHTS : CEREAL GRAINS

Cereal grain breeding, with the exception of corn breeding, remains primarily in the domain of public breeding, although private breeding programs do exist.

Wheat breeders seek to produce varieties that offer excellent milling and processing traits, provide improved production traits, and contribute to safe and nutritious food. Specific breeding targets might include winter wheat with improved quality characteristics for the noodle or flatbread market or hard white wheat with improved Fusarium resistance. Canadian wheat breeders have been world leaders in developing higher protein wheat varieties, without forgoing yield potential. A major breeding goal over the past several years has been resistance to Fusarium Head Blight.

The Western Grains Research Foundation (WGRF) administers the wheat check-off fund, for which deductions are made from Canadian Wheat Board final payments to producers in western Canada. Check-off funds are allocated to wheat breeding programs across western Canada. These programs include, but are not limited to: AAFC Research Centres in Swift Current, Winnipeg and Lethbridge, Alberta; the University of Saskatchewan Crop Development Centre; the University of Manitoba and the University of Alberta; and Alberta Agriculture, Food and Rural Development in Lacombe.

Significant new players, including private interests, have emerged on the wheat breeding scene. Private companies such as Agrico United, AgriPro Wheat and World Wide Wheat are now running breeding programs specifically aimed at western Canada.

For **barley**, Canada invests in research activities for both malting and feed varieties. New varieties offer enhanced stress tolerance and pest resistance, coupled with higher yield potential for stronger, more dependable harvests. Malt barley programs have incorporated improved disease resistance and agronomic performance, while feed barley programs are developing varieties with traits required by the livestock industry. These traits include heavy kernels and improved nutrient availability.

The WGRF administers the barley check-off fund in Saskatchewan and Manitoba, while the Alberta Barley Commission administers a similar fund in Alberta. The main stakeholders in the barley breeding network include the University of Saskatchewan Crop Development Centre, the AAFC Brandon Research Centre and Alberta Agriculture, Food and Rural Development's Field Crop Development Centre in Lacombe, Alberta.

For **oats**, breeders have developed varieties of milling quality oats and have produced varieties for specific feed and food markets. Currently there is no producer check-off funding in place, but breeding programs do receive funding from processors, such as Quaker Oats, which has been funding research for a long time. In 1996, the Prairie Oat Breeding Consortium was created to bring industry funding together to fund public research. The contributing partners include Quaker Oats, General Mills, Popowich Milling, Can-Oat Milling, Emerson Milling, Quality Assured Seeds, SeCan, Cargill and Pioneer Hybrid Australia.

Plant breeding activities, while limited, also exist for **rye** and **triticale**, while work is done to select **corn** varieties best suited for the Prairie climate.

1980s, one variety of canola was granted rights every second year. In 2004, 24 new canola varieties were granted rights and all were developed in the private sector. The availability of numerous varieties suitable for cultivation in Canada has provided numerous opportunities and challenges to the marketplace.

PLANT BREEDING IN WESTERN CANADA

In western Canada, the main plant breeding institutions include: Agriculture and Agri-Food Canada (AAFC) with seven research centres in western Canada; provincial government agriculture departments, especially Alberta Agriculture, Food and Rural Development; Universities with agricultural colleges, especially the University of Saskatchewan's Crop Development Centre; and private companies such as Monsanto, Pioneer Hi-Bred, Dow AgroSciences, and Syngenta. For some crops, like canola, grain companies such as Saskatchewan Wheat Pool and Cargill are also active in plant breeding. Typically, work will be done in collaboration with other institutions, and projects receive more than one source of funding.

Most plant breeding institutions specialize in one crop type or group of crop types. For instance, AAFC's Cereal Research Centre is known for its work in wheat and oats research, while AAFC's Saskatoon Research Centre is more involved in oilseed and forage research.

Major funding sources vary by crop. For wheat and barley, producer check-offs on Canadian Wheat Board delivered grains are redistributed to fund research through the Western Grains Research Foundation. An exception is the check-off on barley grown and delivered in Alberta, which is collected and distributed by the Alberta Barley Commission. Producer check-offs are also used by most commodity groups, including, but not limited to; canola, flaxseed, soybeans, pulse crops, sunflowers, mustard and buckwheat.

Other major research funding partners in Canada include: the grain companies, especially Agricore United and Saskatchewan Wheat Pool; processors, especially Quaker Oats and Anheuser-Busch; other players in the seed industry, such as

SeCan; and the Canadian Wheat Board.

PLANT BREEDING PROCESS

The five key stages of variety development, which are similar to those outlined by Meristem Information Resources Ltd. in its publication *Land & Science*, are: 1) Develop a Breeding Strategy; 2) Gather key traits; 3) Test top prospects in real field situations at numerous locations across the Prairies; and where applicable, depending on the crop type, 4) Receive a recommendation for registration; and 5) Apply for Variety Registration with the CFIA.

Developing a breeding strategy means setting goals. Typical goals include increasing agronomic flexibility and productivity, capturing niche markets and/or offering end-users more options. Included in this list might be features such as improved yields and yield stability, maturity, hardiness, disease and pest resistance and specific product attributes. At this stage plant breeding institutions gather broad input from a variety of stakeholders in order to develop breeding strategies based on a wide range of production and market factors. Whether the goal is to find a niche and fill it, improve the performance over existing varieties, or develop an innovative product, the strategy ultimately involves targeting a complex mix of traits.

Plant breeders rely on formal and informal networks of "advisors" to increase the likelihood of developing a product the market wants. Stakeholders contacted are numerous and include producers, processors, and other industry players, such as grain handling companies, exporters and retailers. Agricultural associations, marketing boards, provincial government extension workers, seed dealers, private crop consultants, other researchers in plant breeding and other fields, health and nutrition professionals, and consumers might be consulted as well. The formation and use of advisory committees,

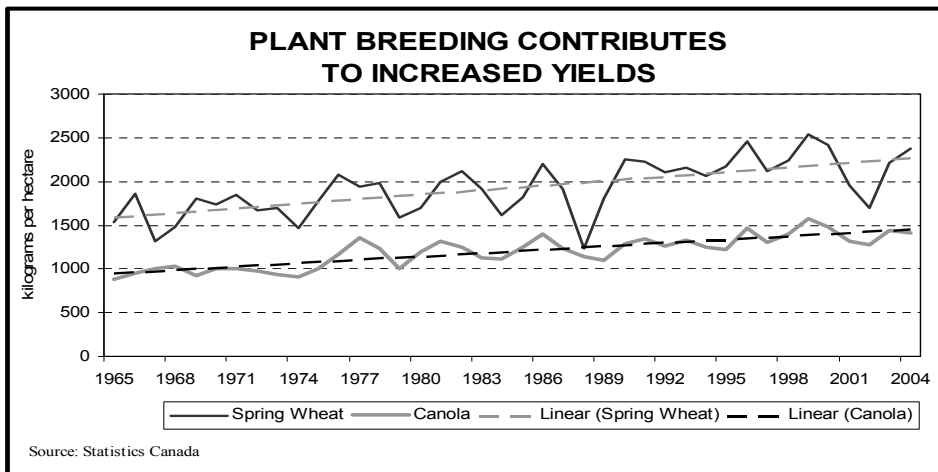
RESEARCH HIGHLIGHTS : OILSEEDS

There has been a major move from public to private plant breeding for all oilseed crops. Private researchers now register most canola and soybean varieties, and conduct significant work in the areas of flaxseed and linola. Important public sector canola breeding programs remain at the AAFC Saskatoon Research Centre and the Universities of Manitoba and Alberta, while flaxseed is bred at the AAFC Cereal Research Centre in Morden, Manitoba and the University of Saskatchewan.

Canola is a Canadian plant breeding success story. Developed by Canadian breeders in the 1970s, this low-erucic and low-glucosinolate relative of rapeseed has become Canada's most produced oilseed for domestic and export markets.

Private and public plant breeders strive to improve upon canola's low saturated fatty acid profile by breeding specialty canola varieties designed to meet ever-changing nutritional and industrial needs. Research continues into breeding canola adapted to a wide range of climatic conditions, with high vigor and strong pest and disease resistance for consistent, excellent yields. New canola varieties must meet minimum criteria for yield, oil content, protein content, fatty acid profile, glucosinolate content and disease-resistance. In response to concerns about trans fat in partially hydrogenated vegetable oils, canola breeders continue work to develop canola lines that produce oils with a high oleic and low linolenic acid content.

For **flaxseed**, breeders seek continual improvement in the iodine value, oil and protein content. For **soybeans**, western Canadian farmers are benefiting from early-season varieties.



expert committees and provincial committees have been essential in communicating market signals across the value chain, to and from the research community.

While plant breeders have research targets specific to their organization, they must be aware of the targets of potential funding partners as well.

Gathering key traits is the process of searching for the required traits and creating them if they don't exist. Breeders begin by gathering a large number of crop lines, known as the germplasm pool, which may contain the targeted traits. Lines are screened for these traits, and the desirable ones are bred with adapted lines. Further selection over several generations allows the breeder to develop a single line or hybrid that has all of the targeted traits fixed in its genetics. The process is long, with many years devoted to varieties that may never make it through the

registration process.

There are many scientists devoted to germplasm, or trait, research, and their work directly feeds into the work of the plant breeder. Germplasm researchers aim to identify germplasm with useful characteristics such as pest resistance and improved quality, determine the genetic control of these characteristics and catalogue these traits in a manner which is useful to plant breeders. For example, the AAFC Semiarid Prairie Agriculture Research Centre at Swift Current, Saskatchewan, has located two new sources of stem solidness, which could provide resistance to the sawfly pest. AAFC researchers are working to incorporate these genes, which have been identified in an unrelated plant, into adapted wheat varieties. This way sawfly resistance can be made available to wheat breeders, should the current source become vulnerable to the pest. The

Canadian seed gene bank, Plant Gene Resources of Canada, located in Saskatoon, Saskatchewan, has a comprehensive collection of cereal germplasm from around the world.

Biotechnology and advances in genetic engineering have provided researchers with more tools to do their job and have resulted in accelerated progress towards improving production and processing traits. Today scientists specifically devoted to the task of gene mapping have greatly improved the knowledge of how and why plants exhibit certain traits. In their work to learn what makes one plant variety more capable of fighting off disease than another, molecular plant geneticists are identifying and mapping the genes that allow plants to resist fungi, viruses, nematodes and bacteria. Once a resistance gene is isolated, researchers go one step farther to identify the proteins produced by the identified genes. This work is referred to as genomic research. Canada, through Genome Canada, coordinates and collaborates with an international network of countries to pursue this research which is so valuable for today's plant breeders.

Prairie-wide testing evaluates the crop line under actual growing conditions. Canada is a vast country, and even within western Canada there are many different climatic zones and soil types. These Prairie-wide tests, known as "co-op" trials, are a cooperative effort among

RESEARCH HIGHLIGHTS: PULSE AND SPECIAL CROPS

Public and private plant breeding programs aim to produce varieties adapted to Canadian climatic and soil conditions. Canada's pulse seed production includes dry peas, lentils, dry beans and chickpeas, while its main special crops are mustard seed, canary seed, sunflowers and buckwheat. Several producer groups in western Canada have implemented a producer check-off fund to offset the costs of research. These groups include: the National Sunflower Association of Canada; Pulse Growers Associations in Manitoba, Saskatchewan and Alberta; the Saskatchewan Mustard Development Commission; and the Manitoba Buckwheat Growers Association.

FORAGE CROPS

Canada is a world leader in the breeding of forages for a wide variety of markets and climates. There are two public breeding programs in western Canada, located at AAFC Saskatoon and AAFC Lethbridge. Varieties of some species, notably alfalfa, are developed by programs in eastern Canada and the United States, and are widely used in western Canada. Breeding programs seek to improve on existing varieties for pasture, hay, soil conservation, and turf purposes.

breeding institutions.

The co-operative trials are administered by Recommending Committees, including the Prairie Registration Recommending Committee for Grain (PRRCG), or the Western Canada Canola/Rapeseed Recommending Committee (WCC/RRC) in the case of canola.

Co-op tests involve three years of field evaluation (two years, with an option of a third for canola) at many locations, extensive disease resistance screening at a variety of AAFC research stations, and may include quality testing at the Canada Grain Commission's Grain Research Laboratory. Varieties that pass this rigorous testing can be proposed by the plant breeder for a recommendation for registration at a recognized Recommending Committee meeting. For cereals, oilseeds and special crops, the committee in western Canada is the PRRCG or the WCC/RRC, which both hold their annual meetings in February.

Evaluation and recommendation for registration is an essential step in the registration process, for most crop kinds. Two key decision making bodies for registration of new varieties of grains and oilseeds in western Canada are the PRRCG and the WCC/RRC. Both committees evaluate test data, including agronomic, disease and quality parameters, presented by plant breeders and other researchers and make recommendations to the CFIA either for or against registration of prospective cultivars.

Varietal Registration, for most crop kinds, is the formal process of obtaining registration of a variety from the CFIA. Canada's variety registration system has been in place since 1923 when the original 1905 Seeds Act was amended to require varieties to be licensed by the Minister of Agriculture, prior to sale in Canada. During the 80 years of variety registration, over 5,500 varieties have been registered, with over 70% of them in the past 30 years.

There are some crops which do not require CFIA registration. However, in order to facilitate documentation and certification, these crops are listed. Examples of listed crop types include grain corn, soybeans for food use, some turf grasses and heritage species.

The *Seeds Act and Regulations* is the federal legislation governing the testing, inspection, quality and sale of seeds in Canada. Part III of the *Seeds Regulations* (Sections 63 to 77) concerns the variety registration system.

In Canada, varieties are currently registered on the basis of merit. The variety registration system has three mandates: to ensure that agronomically inferior or unadapted varieties are excluded from the Canadian marketplace; to ensure that new varieties meet current requirements for resistance to economically important diseases; and to ensure high quality products for processors and for consumers. Proposed varieties undergo merit testing for agronomic, disease and quality traits.

For a variety to be registered, a plant breeder or plant breeding institution must submit an application to the Variety Registration Office of the CFIA. A complete application package contains information necessary to verify the uniqueness of the variety, its merit and the necessary information for crop inspection and varietal purity testing. Some of the information requirements are as follows: 1) a proposed variety name; 2) the scientific and/or common name of the species; 3) a description of pedigree, origin, history and methods of development of the variety; 4) a copy of the Recommending Committee experimental trial results; 5) a valid recommendation for registration from a recognized recommending committee, 6) a representative reference sample, and, 7) a description of the variety.

When a variety is registered, the CFIA Registrar issues a certificate of registration to the applicant. Unless

otherwise specified, the registration is valid for all provinces and territories of Canada, until such time as the registration is cancelled or suspended, usually at the request of the breeder.

PLANT BREEDING IN CANADA IS IN THE MIDST OF TRANSFORMATION

For decades, Canada has been able to provide consumers, both at home and abroad, with high quality product that meets or exceeds customer expectations. Until recently, consumers demanded a high quality product in bulk volumes, and Canada's institutions were able to deliver it. Now, in addition to bulk commodities, Canada's customers are demanding highly specified products, often referred to as niche commodities.

Canada's institutions in the seed industry were developed to ensure quality and safety of bulk commodities. In order to prepare for tomorrow, many of the pillars of Canada's agricultural industry have come under scrutiny. Everything from variety registration to the current grading system to kernel visual distinguishability is under review. The Seed Sector Review, restructuring of the PRRCG, and the Variety Registration Review will all greatly impact the plant breeders' objectives and are discussed below.

Seed Sector Review

Public and private plant breeders form an integral part of the seed sector, which also includes pedigreed seed producers, commercial growers and the seed trade. Together, the seed sector aims to: 1) improve the agronomic performance of field and horticulture crops; 2) improve resistance to pests and diseases which are economically significant or which pose threats to animal and/or human health; 3) respond to traditional and new requirements of primary and end-use consumers in domestic and export markets, and; 4) use the potential of new science to satisfy consumer demands for health, function and environmental stewardship.

In May 2004, the Seed Sector Advisory Committee, featuring the Canadian Seed Growers Association, the Canadian Seed Trade Association, the Grain Growers of Canada and the Canadian Seed Institute, published a report outlining a strategic outlook for the future of Canada's seed industry. The report provides an overview of the perceived strengths, weaknesses, opportunities and threats facing the seed sector and provides recommendations for change in the sector. This industry-led, industry-wide assessment noted that industry practices, technology, globalization, consumer preferences and new market opportunities have contributed to a dynamic and challenging environment for the seed sector.

The Advisory Committee stated that domestic and international competitiveness will require the achievement of four broad results: regulatory flexibility and timeliness; a supportive environment for science and innovation; profitability of the sector; and consumer acceptance and confidence.

Specific recommendations from the report include: implementing a permanent, industry-led, consultative body to provide advice on policy, a mechanism for industry consultation and a forum for industry/government dialogue; restructuring the variety registration system to create a more flexible system of registration information requirements based on crop kind; and ensuring that Canada continues to provide a risk-based environment that supports and rewards innovation.

Prairie Registration Recommending Committee for Grain

The PRRGC is made up of four sub-committees: 1) wheat, rye and triticale; 2) barley and oats; 3) oilseeds, excluding canola; and 4) special crops. Each of these sub-

committees has three expert evaluation teams to objectively examine test data on agronomic performance, disease response susceptibility and processing quality.

In February 2004, the PRRGC voted in favour of dissolving the collective committee and shifting full powers to its four crop-specific subcommittees, allowing them to become independent recommending committees, effective April 1, 2005. The resolution is largely the result of the desire for greater control among the subcommittees to handle appeal processes and other governance issues. As well, the restructuring will allow the crop type-specific committees to deal directly with CFIA's Variety Registration Office (VRO). This resolution will be forwarded to the VRO in order for individual committees to be recognized.

Variety Registration

The CFIA has been engaged in consultations since 1998 to prepare for major changes to the existing Variety Registration system. The next step in the review process was the Seed Sector Review, as described above. The outcome of the Seed Sector Review is being evaluated in order to determine what areas require further consultation before proceeding with developing a new regulatory proposal.

While the CFIA has yet to develop a final proposal, it has identified a number of key areas of consensus. These include the need to: maintain merit and/or performance testing requirements, where required; maintain a capability to deal with consumer confidence, especially in health and safety issues; and, increase the flexibility and responsiveness of the current regulatory amendment process.

Although still under discussion, there is a general trend to move away from the merit principle as a key pillar of

variety registration. It is likely that the CFIA will retain mandatory merit requirements for some agricultural crops in order to provide assurance to producers, processors and consumers. For other crop types, some form of varietal recognition will be retained in order to facilitate seed certification, which is the foundation for the quality control that supports both domestic and export sales.

*For further information on the ongoing reform, please visit The Seed Sector Review at www.seedsectorreview.com
The Variety Registration Review at www.inspection.gc.ca*

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