Exploring Options for Producer Involvement in Wheat and Barley Variety Development

Annexes

Prepared for
Wheat and Barley Variety Working Group

Prepared by
JRG Consulting Group
a division of 1260977 Ontario Inc.
Guelph, Ontario
(519) 836-1860

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Annex A - Wheat and Barley Variety Development in Western Canada Today

There are a number of institutions involved in wheat and barley variety development in western Canada. These range from public sector bodies such as Agriculture and Agri-Food Canada (AAFC), Alberta's Field Crop Development Centre (FCDC), the Crop Development Centre (CDC) at the University of Saskatchewan (U of S), the National Research Council (NRC), the University of Alberta (U of M), University of Manitoba (U of M) and private sector bodies such as Bayer Crop Science, Canterra, and Syngenta. The majority of plant breeding of wheat and barley is through public sector institutions. In this section a brief overview is provided of the institutions and partnerships involved in variety development and their respective roles. First, an overview is provided of the overall variety development system for self-pollinating plants such as wheat and barley and a discussion of why public institutions have been involved in variety development of wheat and barley.

A.1 Current Producer Involvement in Variety Development

Producers have also been involved in variety development of wheat and barley in western Canada for over three decades through the WGRF, a non-profit organization, where producer organizations are well represented on the WGRF's Board. The WGRF was created in 1981 as a research funding organization that would partner with research providers, with initial funding provided by the federal government when the Prairie Farm Assistance Act was no longer in effect. The Canadian Wheat Board (CWB) used to collect Wheat and Barley Check-offs as a deduction on final payments ($0.30 a tonne for wheat and $0.50 a tonne for barley), and in 1993 these funds were then administered by WGRF. These levies are WGRF's major source of funds for wheat and barley variety development, and currently first receivers of wheat and barley collect the check-offs and submit the proceeds to the WGRF. The 2012 change in the status of the CWB required a different approach to collecting the check-offs that supported WGRF's investments in variety development. Currently, the check-offs are collected from first receivers by the Alberta Barley Commission (ABC), with this authority expiring on July 31, 2017. This temporary program (The Western Canada Deduction) was put in place to allow some time for the industry to develop a long term funding model for important programs such as variety development. The WGRF has contracts for wheat and barley development through 2019.

The WGRF invests check-off funds into wheat and barley breeding research through long term agreements and individual projects with public institutions. In the last crop year, the WGRF collected $7.7 million in wheat check-offs and invested $6.1 million in variety development. For barley just under $1 million was collected through the WGRF check-off and $1 million was invested in variety development. WGRF leverages this money by sharing the costs of public research with governments and other contributors to wheat and barley breeding programs. WGRF invests in wheat and barley breeding programs at AAFC institutions and the three prairie universities: the University of Manitoba (U of M), the University of Saskatchewan (U of S), and the University of Alberta (U of A) and at the Alberta Field Crop Development Centre (FCDC). WGRF has assisted in the development and release of more than 200 new wheat and barley varieties over the past 20 years, many of which are today seeded to large portions of the cropland in Western Canada.

The Alberta Barley Commission has also supported variety development programs at the FCDC through their check-off system, which has been in place since 1991. The recent creation of the other provincial wheat and barley Commissions and their provincially based check-off authorities provides a greater opportunity for producer involvement in variety development. In the last crop year, these organizations received $16 million in check-off levies, and made investments of approximately $1.5 million in variety development[1].

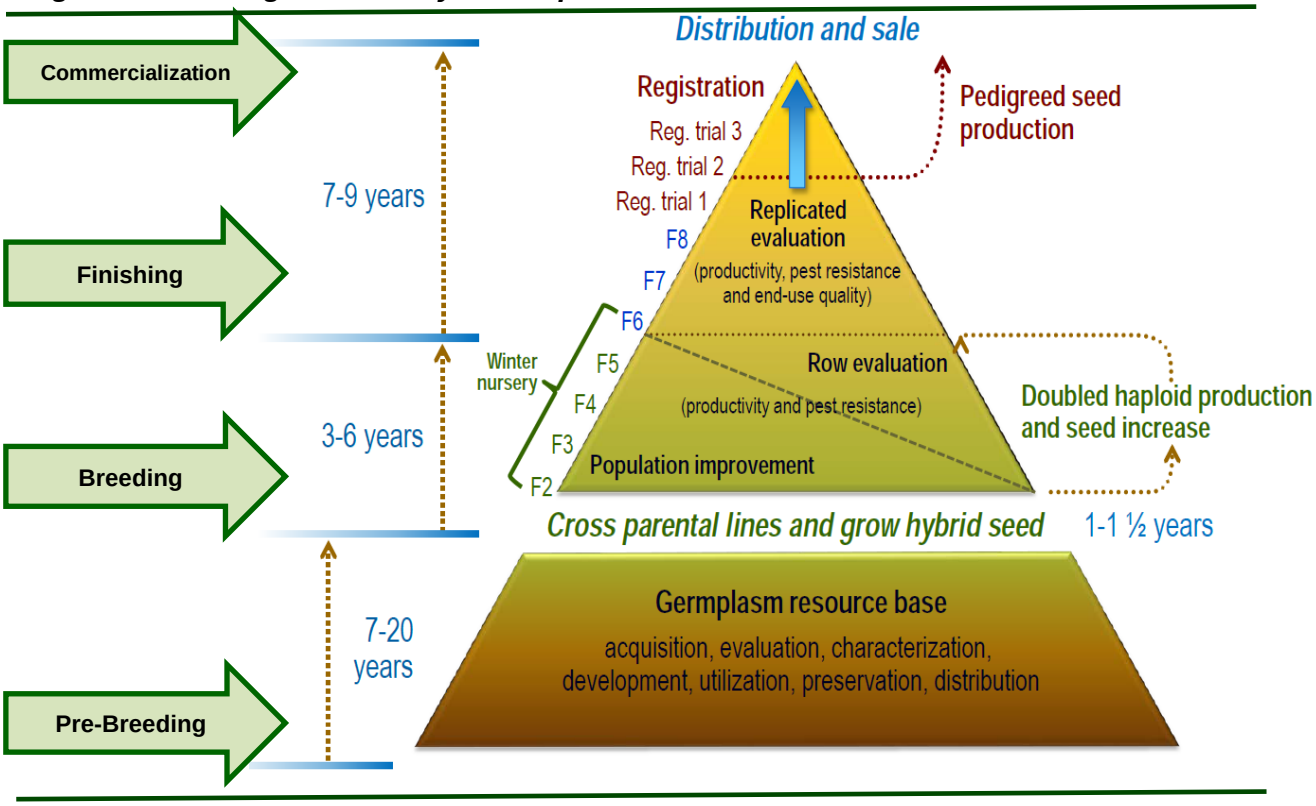
[1] These check-off funds can be used for other areas such as agronomic research, marketing, promotion, etc.

A.2 Stages in Variety Development

The expression "variety development" is used rather than the more familiar term of plant breeding, since variety development encompasses more than plant breeding. Stages of variety development, as used in this report and as shown in Figure A.1, include[2]:

- Pre-breeding, which includes discovery, germ plasm development, genomics, development of breeding tools, development of evaluation, etc.;
- Breeding, which is the breeding of a number generations (e.g., F1 to F7 or F8) of a crop kind;
- Variety finishing, includes finishing, replication, and registration; and
- Commercialization, which is the distribution and sale of a registered variety.

Figure A.1 Stages in Variety Development



The term pre-breeding is used in this report to describe the discovery research that precedes actual plant breeding activities. Pre-breeding activities typically generates "knowledge" and "know how" that can be used in breeding programs, and as discussed below these activities are typically public and industry goods. Not all plant breeders used this terminology in Canada; it is used in other jurisdictions such as Australia. Pre-breeding has been defined in Australia[3] as "*pre-breeding is R&D intended to contribute to genetic improvement for a trait or traits of economic value. It is often undertaken outside a commercial breeding program, but with the intent of providing improved germplasm, screening technology or breeding methods. Pre-breeding may include gene discovery, trait identification, developing markers, phenotypic screens and information generation*".

[2] The major portion of Figure 1.1 is from "*AAFC and the Future of Cereal Breeding*", presentation by Drs. Stephen Morgan Jones and George Clayton, Science and Technology Branch, AAFC..
[3] "*Grains Industry, National Research, Development and Extension Strategy"*, Australia 2011, Primary Industries Standing Committee – R&D Subcommittee April 2011.

Breeding begins with the crossing of two parental lines (F1 generation) to create the F2 generation, from which breeders select and replicate through successive generations as highlighted in the above schematic.

These stages in the variety development process will be referenced a number of times throughout the report. There is a direct linkage between the stage of variety development and whether it is a major focus of public sector institutions and the private sector. For example, most discovery research (or pre-breeding activity) is conducted by public institutions, such as universities and AAFC, particularly when the resulting knowledge can be freely used by others[4]. Private sector firms (i.e., seed companies) in western Canada tend to focus more on commercialization, finishing and some breeding. This institutional focus is largely due to the nature of the good being developed – is it a public good or an industry good that can be easily shared with others.

A.3 Public Good Aspects of Variety Development

Economists refer to goods as public goods or private goods based on whether or not others can be excluded from enjoying the good, and whether or not if consumption by one results in others not being able to enjoy the same good. This is illustrated in Figure 2.2 based on whether the good does, or does not, have exclusion properties and rival (subtractable) properties. Rival means that consumption (use) by one reduces the amount available to others, and excludable means whether or not others can be excluded from consumption (use).

Figure A.2 Public Goods and Non-Rival and Non-Excludable

		Excludable	
		Yes	**No**
Rival	**Yes**	Private Goods	Common-Pool Resources
	No	Toll Goods	Public Goods

Private goods are almost self-evident, such as an ice-cream sandwich once eaten, cannot be consumed by others. A toll good (or a club good) is one where exclusion is possible through membership fees, and once consumption by one member occurs then such use does not reduce consumption by other, such as cable television. A common pool resource can include a park (or ocean fisheries), where exclusion is difficult; however, use by one can affect use by others.

A public good is where exclusion is not possible and where consumption by one does not affect (or subtract from) consumption or use by another. Plant genomics and basic science research discovery can be viewed as a public good simply due to the fact that knowledge is difficult to exclude and spillover to non-market participants, while the use of knowledge by one party does not diminish the ability of another party to access that knowledge. Another characteristic of a public good is that the marginal cost to supply an extra unit is essentially zero. For example, once knowledge is created, it can be provided to one entity at the same cost as supplying it to many.

There is a difference between the non-excludable good of “knowledge” versus “know how”, which can be excludable. For example, pre-breeding genetic modification technology was essentially the development of “know how”, which as an excludable good allowed private firms to capture the value of such technologies.

[4] GMO technology was developed by the private sector since the value of the technology could be captured through licensing and/or seed sales.

Knowledge spillovers often define natural roles for public, private and producer investment. Agricultural innovation and productivity improvement includes the creation and application of a very wide range of knowledge. Table A.1 itemizes some of the types of knowledge common to most agricultural innovation systems. The three columns in the table sort this knowledge according to the nature of spillovers, which corresponds to the fundability by private firms, producer (industry) groups, and governments.

Table A.1 Public and Private Goods in Variety Development and Crop Production

Public Goods (non-excludable)	Industry Goods (non-excludable)	Private Goods (excludable)
Basic Science Research	Crop genomics, germplasm, unprotected varieties	IP Protected crop varieties/traits/processes
Science literacy/ ecology /chemistry/ biology	Agronomy/ best management practices	Protected production process
Business management	knowledge dissemination product, input testing	Patentable mechanical innovations
Human and model crop Genomics	Crop disease research, biological control systems	Chemical Pesticides Inoculants
Pathogen Research	Quality standards/systems Market access	product and market development

Source: Gray (2014)[5]

The third column of Table A.1 includes the types of knowledge where strong Intellectual property rights (IPRs) exist and private research firms can capture the value from the fruits of their research effort. Goods in this category include hybrid or patent protected varieties, patented pesticides, patented machinery, etc.

The middle column in the table includes knowledge often referred to as industry goods. Like public goods, these goods are non-excludable (and non-rival). Unlike public goods the knowledge spillovers are primarily confined to the industry. For example, yield-increasing wheat research is likely to most directly benefit producers and consumers in the wheat industry, but will not tend to spillover to non-wheat consumers. Research for this type of knowledge can be effectively supported from producer levies or check-offs, where the industry participants paying for the research receive the non-excludable benefits.

Finally, the first column in Table A.1 includes non-excludable knowledge that provides broad public benefits, well beyond a specific industry. For example, the discovery of DNA, while benefiting agriculture, has benefits well beyond the sector.

Knowledge spillovers curtail incentives and restrict the domain for private and industry investment. The private sector can only capture value when spillovers are limited and will tend to invest only in private goods. Industry groups on the other hand have an incentive to invest in both industry goods and private goods, but have very limited incentive to invest in public goods, as these benefits spillover to those outside the group. The public (or governments) can invest in public, industry or private goods.

[5] Gray, Richard. "*Solutions to the Agricultural Research Funding Conundrum" Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie* 62.1 (2014): 7-22.

With limited agricultural investment resources for government or industry groups, specific investment roles tend to emerge from this classification. If industry groups focus on research to produce industry goods, while the public sector focuses on research that creates public goods, the crowding out effects on private investment tend to be minimized and overall research investment tends to be maximized. This effect is particularly important where the private sector controls a pool of important knowledge and genetics. The delineation of roles is also important because research of a public good nature is an essential, but often limited, input into agricultural innovation that can only be funded by taxpayers.

This feature of non-excludability for unprotected crop varieties such as farmer-saved seed means that a seed company has difficulty capturing a return or royalty on a new variety once it is released. With a self-pollinating non-hybrid crop such as wheat, the farmer-saved seed; (the next generation) can in many cases provide a yield that is comparable to certified seed. With weak crop variety protection, a breeder is able to charge for sales of certified seed; however, they are not able to restrict the ability of the farmer to save the seed in order to reuse the same variety on their farm for years and years. Perrin and Fulginity[6] (2008) estimate that with these types of rights, private firms often capture 11% of the value that they create.

In this environment where royalties cannot be captured on all seed planted each year, the incentive structure is low for seed companies to invest in varietal development. As a result, public institutions have been the major investors in varietal development of cereals such as wheat and barley. In contrast, as shown elsewhere in this report, with corn hybrids and the need to purchase seed corn each year (i.e., excludable), seed companies can price accordingly to capture the value created to fund continuing improvements in seed corn hybrids.

Seed companies providing new varieties of wheat and barley are also constrained as to how much of a royalty they build into certified seed sales. If it is too large, this will discourage farmers of self-pollinating crops such as wheat from purchasing certified seed, as they know the yields they can achieve with farmer-saved seed and with previously licensed varieties.

This inability to repeatedly capture a large portion of the value created with a new variety limits the amount of private sector investment in wheat and barley compared to crops such as corn or canola. Within Canada, private sector investment in wheat and barley accounted for less than 0.2% of the value of wheat and barley sales in 2012[7]. This contrasts with private sector investment in canola variety development that was 0.8% of canola's farm cash receipts – at least a four-fold increase. On corn and soybeans, the private sector investment in variety development was 0.7% and 0.4%, respectively. In absolute dollars, $6.2 million was invested in wheat variety development by the private sector (CSTA members) and $1.7 million in barley in 2012[8]. In contrast, public expenditures on variety development for wheat are estimated to be in the neighborhood of $34 million per annum and $7.0 million for barley. Producer expenditures that complemented these public expenditures are in the neighborhood of $6.0 million for wheat and $1.5 million for barley[9].

With the change in the PBR Act, the opportunity exists for royalties to be collected on seed used each year, including crops marketed using farmer saved seed. End Point Royalties (EPR) are used in other countries that have signed on to UPOV 91. How EPRs can be used is described in Annex B and examples of how they have been successfully used are illustrated in Annex F.

[6] Richard K. Perrin and Lilyan E. Fulginiti, "*Pricing and Welfare Impacts of New Crop Traits: The Role of IPRs and Coase's Conjecture Revisited" AgBioForum, 11(2): 134-144. (2008)*

[7] Based on "*CSTA Investment Survey Results*", 2012.

[8] This contrasts with $64.8 million for canola and $16.5 million for corn.

[9] Annex B provides data on private sector, wheat and barley producer, and public sector spending on variety development. See Table B.2 in Annex B.

A.4 Public Institutions, Private Sector and Partnerships in Variety Development

A number of organizations in western Canada are involved in variety development for wheat and barley, and include provincially mandated Commissions, producer organizations, private sector companies, federal government departments, provincial governments, and other collaborative organizations. These organizations typically have specific roles in variety development and can have some type of producer involvement. Tables A.2 and A.4 provide a summary based on type of organization, crop kind focus, role in variety development, and the type of producer involvement.

Producer commissions and organizations help fund varietal research through refundable levies. The groups involved are as follows:

- British Columbia Grain Producers Association: administers the producer levies for the Peace River Agricultural Development Fund; mission is to "*improve the viability of the grains and oilseed industry in the BC Peace River Region*".
- Alberta Wheat Commission: established in 2012 and replaces two specialty wheat commissions; its objective is to "*increase the long term profitability of all Alberta wheat growers through funding innovative research, market development and promotional activities, producer education programs, and policy development*".
- Alberta Barley Commission: established in 1991 to benefit the barley sector; the first producer commission established; its mission is to "*bring added value to barley production*."
- Saskatchewan Wheat Development Commission: established in 2013; its mission is to "*to provide leadership in identifying and supporting research and market development that contributes to profitable and sustainable wheat production for Saskatchewan farmers*."
- Saskatchewan Barley Development Commission: established in 2013; its mission is to *"to identify, develop and support research, market development, and extension initiatives that ensure long term profitable and sustainable barley production for Saskatchewan farmers"*
- Saskatchewan Winter Cereals Development Commission: established in 2008 to represent producers of winter wheat.
- Manitoba Winter Cereals Inc.: Development Commission: established in 2008 to represent producers of winter wheat.
- Manitoba Wheat and Barley Growers Association: established in 2014 to "*to strategically invest in research and market development initiatives that advance the profitability and sustainability of wheat and/or barley production for growers.*"
- WGRF: established in 1981; it "*is a farmer funded and directed charitable foundation investing in agricultural research that benefits western Canadian producers*".

Private sector companies involved in wheat and barley variety development include:

- FP Genetics: provides some funds to CDC for wheat breeding;
- Canterra Seeds: provides some funds to AAFC for wheat breeding;
- SeCan: provides some funds to AAFC for wheat breeding and to the CDC;
- Bayer Crops Science: recently established a breeding station at Pike Lake Saskatchewan, focusing on hybrid wheat and also provides funding to CDC;
- BASF, Bayer, Busch Ag (Anheiser Busch), Cargill Ltd., Agrium (via Crop Production Services Canada), FP Genetics, Molson Coors, Sapporo Brewery, and Viterra provide funding to CDC's variety development.
- Syngenta: partnering with Canadian Wheat Alliance and KWS, a large German plant breeding company;
- Western Feed Grain Development Corporation: A producer cooperative which breeds general purpose wheat;
- Ag Quest, focuses on contract research supporting variety development; and
- Alliance Seeds, distributes AAFC varieties and also funds variety development.

Table A.2 Western Canada Organizations Involved In Wheat/ Barley Variety Development

Organization	Type	Crop Kind	Role in Variety Development	Producer Involvement
Producer Commissions/Organizations				
BC Grain Producers Association	Producer	Wheat and Barley	Funder via BC Peace River Grain Industry Development Council	Producer Organization
AB Wheat Commission (AWC)	Producer	Wheat	Funder and Influencer	Producer Commission
AB Barley Commission (ABC)	Producer	Barley	Funder and Influencer	Producer Commission
SK Wheat Development Commission (SWDC)	Producer	Wheat	Funder and Influencer	Producer Commission
SK Barley Development Commission (SBDC)	Producer	Barley	Funder and Influencer	Producer Commission
SK Winter Cereals Development Commission (SWCDC)	Producer	Winter Wheat	Funder and Influencer	Producer Commission
MB Wheat and Barley Growers Association (MWBGA)	Producer	Wheat and Barley	Funder and Influencer	Producer Commission
Winter Cereals MB Inc. (WCMI)	Producer	Winter Wheat	Funder and Influencer	Producer Commission
Western Grain Research Foundation (WGRF)	Producer	Wheat and Barley	Funder, Influencer & Coordinator	Charitable Foundation
Private Sector				
FP Genetics	Private	Wheat	Funder	None
Ag Quest	Private	Wheat and Barley	Contract Research	None
Canterra Seeds	Private	Wheat and Barley	Funder	None
Alliance Seed	Private	Wheat and Barley	Funder	None
SeCan	Private	Wheat and Barley	Funder	None
Syngenta	Private	Wheat	Funder and Researcher	None
Bayer Crop Science	Private	Wheat	Funder and Researcher	None
Western Feed Grain Development Corporation (WFGDC)	Producer	Feed Wheat	Researcher	Producer Co-op
Private sector funders at CDC (Agrium, Bayer, BASF, Busch Ag, Cargill, Molson Coors, FP Genetics, Sapporo, SeCan and Viterra	Private	Wheat and Barley	Funders	None

Two federal government institutions are involved in wheat and/or barley variety development in Western Canada: AAFC funds and conducts research to develop new wheat and barley varieties, and the NRC funds and conducts research. There are nine (9) wheat breeders in AAFC research stations in western Canada and two (2) barley breeders, as reported in Table A.3. Producers, through WGRF, provide both core funds and project funding for AAFC plant breeding activities.

Table A.3 Wheat and Barley Breeders in Public Institutions

Public Institution	Wheat Breeders	Barley Breeders
AAFC Brandon	Andrew Burt Santosh Kumar	Ana Badea Bill Legge
AAFC Lethbridge	Rob Graf Harpinder Randhawa	
AAFC Swift Current	Richard Cuthbert Fran Clarke Ron Knox Yuefeng Ruan	
FCDC	Aljarrah Mazen	Pat Juskiw Joseph Nyachiro
CDC (U of S)	Curtis Posniak Pierre Hucl Brian Fowler	Aaron Beattie
U of A	Dean Spaner	
U of M	Anita Brule-Babel	

The Province of Saskatchewan and the Province of Manitoba fund varietal research. The Province of Alberta funds both wheat and barley variety development (by other organizations) and also conducts wheat and barley varietal research at the Field Crop Development Centre (FCDC) in Lacombe. The FCDC is a tripartite agreement between Alberta Barley, AARD, the Alberta Crop Industry Development Fund (ACIDF), and AAFC.

The University of Alberta (U of A), the University of Saskatchewan (U of S), and the University of Manitoba (U of M) conduct varietal research for many crops. The U of A and the U of M only work on wheat while the U of S works on wheat and barley (See Table A.C). The Crop Development Centre (CDC) is a field crop research organization within the Department of Plant Sciences at the University of Saskatchewan. Producers, through the WGRF, provide core funding to the CDC through Breeding Agreements for wheat and barley. The CDC has a number of private sector co-funders including Bayer Crop Science, BASF, Busch Ag (Anheiser Busch), Cargill Ltd., Crop Production Services Canada (Agrium), Molson Coors, FP Genetics, Sapporo Brewery, SeCan, and Viterra.

In total there are 14 wheat breeders and 5 barley breeders developing new varieties for western grain producers, with 6 developing varieties at universities (See Table A.3 above). Barley breeding occurs at AAFC Brandon, the CDC, and at the FCDC.

There are some other organizations that fund and/or coordinate varietal development in wheat and barley. These are:

- Alberta Innovates Bio Solutions (AI Bio) works with partners to identify, coordinate and fund research projects;
- Barley Council of Canada: founded in 2012 its objective is to grow Canada's barley sector through collaboration, cooperation, and innovation via a value chain approach; members are from throughout the supply chain;
- Genome Canada: a "not-for-profit organization that acts as a catalyst for developing and applying genomics and genomic-based technologies to create economic and social benefits for Canadians";

Table A.4 Western Canada Organizations Involved In Wheat/ Barley Variety Development

Organization	Type	Crop Kind	Role in Variety Development	Producer Involvement
Federal Government				
Agriculture and Agri-Food Canada (AAFC)	Public	Wheat and Barley	Funder and Researcher	AAFC and producers jointly fund research Producers fund AAFC research
National Research Council (NRC)	Public	Wheat	Funder and Researcher	
Provincial Governments				
Government of AB/FCDC	Public	Wheat and Barley	Funder and Researcher	
Government of SK	Public	Wheat and Barley	Funder	
Government of MB	Public	Wheat	Funder	
Universities				
University of Alberta	Public	Wheat	Researcher	Producers fund
University of Saskatchewan - CDC (Crop Development Centre)	Public	Wheat and Barley	Researcher	Producers fund
University of Manitoba	Public	Wheat	Researcher	Producers fund
Other Organizations/Collaborators				
Al Bio	Public	Wheat and Barley	Coordinator and Funder	
Barley Council of Canada	Producer and Private	Barley	Potential Coordinator	Prov. Commissions on the Board
Cereals Canada	Producer and Private	Wheat and Barley	Coordinator and Influencer	Prov. Commissions Members
Genome Canada	Network	Wheat through CTAG	Funder	Co-funder
Genome Prairie	Network	Wheat through CTAG	Funder	Co-funder
Agricultural Funding Consortium	Consortium	Wheat	Funder	Government of AB and producers jointly fund research
AB Crop Industry Development Fund (ACIDF)	Funds from public, producer, and private	Wheat and Barley	Funder	Governments and producers jointly fund research
Major Initiatives				
National Barley Cluster	Major Initiative	Barley	Funded research network	Co-funder
National Wheat Improvement Program	Major Initiative	Wheat	Funded research network	Co-funder
Canadian Wheat Alliance	Major Initiative	Wheat	Funded research network	Co-funder
Canadian Triticum Advancement Through Genomics (CTAG)	Major Initiative	Wheat	Funded research network	Co-funder

- Cereals Canada: a recently founded organization (composed of members throughout the supply chain) with a mission "*to enhance the competitiveness of the Canadian cereals industry by providing leadership on behalf of the value chain to key initiatives of common and strategic interest, including innovation, market development and advocacy*". Cereals Canada could provide a coordinating and funding role in the future;
- Genome Prairie: supports research activity in Manitoba and Saskatchewan;
- Agricultural Funding Consortium: 13 organizations which collaborate to provide one window for funding, which are mostly Alberta based as well as the WGRF;
- Agricultural Crop Industry Development Fund (ACIDF): a non-profit company directed by the crop sector with research strategic goals such as "*increased capability of farmers to manage risk; increased value-chains, new business and markets; increased diversification in the crop sector; improved crop research capacity; and increased consumer confidence in food production*."

Barley and wheat have cluster initiatives underway at the national level. The National Barley Cluster will provide $11 M. over five years. The National Wheat Improvement Program will provide $25 M over five years for wheat breeding.

The Canadian Wheat Alliance is an 11-year collaboration between AAFC, NRC, U of S, and the Government of Saskatchewan. Total funding is approximately $97 M. of which $13 M. is new funding with the remainder funds from existing programming. In-kind support is provided by AAFC and the U of S (through existing programs). The WGRF is a contributor. The Alberta and Saskatchewan Wheat Commissions are reviewing the 2015 CWA/ADF call but have yet to make any funding commitments.

Canadian Triticum Advancement Through Genomics (CTAG) is a major project on wheat genomics, valued at $8.5 M, involves researchers at the U of S; NRC, U of A; AAFC, and the U of R in Canada as well as researchers in France, Switzerland, India, UK, Australia, and the US. WGRF has contributed $3.7 M. to CTAG. AWC and SWDC and WGRF are potential funders of wheat cultivar development research under CTAG (for a CTAG2 project), with an announcement expected in near future.

A.5 Public and Private Wheat Varieties Registered for Use in Western Canada

Producers have many varieties to choose from, particularly in spring wheat with 137 wheat varieties noted on a CFIA database[10]. The majority of these are public varieties; 66% of the registered wheat varieties for use were developed by AAFC, followed by the CDC with 20%, and 10 varieties provided by six universities. A total of nine spring wheat varieties were developed by the private sector, all in the largest class of spring wheat.

In the case of barley, public institutions in western Canada accounted for 19 of 26 registered varieties (see the following tables). Private sector breeders had a larger share in designated varieties used for malt barley, accounting for 40% of designated varieties. The CDC and AARD (FCDC) have developed the majority of public barley varieties in use in western Canada.

The following tables provide information on developers for wheat and barley, and associated acreage share based on crop insurance data. This data shows that private seed companies such as Busch, Monsanto/Westbred, Nickerson American Seed Company, Sapporo/Prairie Malt, Syngenta, Wiersum Plant Breeding, have registered varieties for use in western Canada.

[10] These are varieties currently registered for Western Canada (National or Western Canada region).

The CFIA database on registered varieties [11] is summarized in Table A.5 for western wheat varieties and indicates the number of varieties by product developer. Public varieties are the dominant varieties.

Table A.5 Wheat Varieties Registered for Use in Western Canada

Developer	Western Canadian Varieties			
	Durum	Spring	Winter	Total
AAFC	14	63	13	90
CDC	5	10	12	27
U of Alberta		3		3
U of Guelph			1	1
U of Manitoba		1	1	2
U of Laval		1		1
U of Minnesota		1		1
Cornell			1	1
AARD			1	1
Ontario Agricultural College			1	1
SWP		2		2
Syngenta Canada		4		4
Syngenta US		2		2
Nickerson American Plant Breeders		1		1
Total	**19**	**88**	**30**	**137**

Source: CFIA Variety Registration Database http://www.inspection.gc.ca/active/netapp/regvar/regvar_lookupe.aspx

CWRS wheat is the largest wheat class planted in western Canada, with AAFC varieties comprising the majority of acres, as reported in Table A.6 for 2014. Also shown in the above table is the status of IPR and the developer. A "Y" in the PBR column indicates that Canadian plant breeder rights exist or have been applied for (the seed can't be sold without permission and royalty payment). Clearfield varieties (with a "CL" at the end of the name) have contract restrictions. There is some diversity in developers of CWRS wheat, including a few private seed companies.

[11] The Canada Grain Commission publishes information regarding the acreage by variety using insured acres from provincial crop insurance agencies.

Table A.6 Canada Western Red Spring (CWRS) Varieties and Share of Acreage, 2014

CWRS Varieties	Acres	Share	PBR	Developer
CARBERRY	1,241,683	11.0%	Y	AAFC
HARVEST	1,171,651	10.4%	Y	AAFC
STETTLER	1,018,020	9.0%	Y	AAFC
CDC UTMOST	853,238	7.6%	Y	CDC
LILLIAN	804,059	7.1%	Y	AAFC
CDC GO	750,026	6.7%	Public Release	CDC
CDC STANLEY	535,179	4.7%	Y	CDC
UNITY	446,772	4.0%	Y	AAFC
SHAW	419,900	3.7%	Y	AAFC
GLENN	408,267	3.6%	Y	NDSU
CARDALE	307,760	2.7%	Y	AAFC
VESPER	230,766	2.0%	Y	AAFC
MUCHMORE	229,055	2.0%	Y	AAFC
CDC ABOUND	218,795	1.9%	Y	CDC
MCKENZIE	138,376	1.2%		SWP
5604HR CL	137,252	1.2%	Y	Syngenta
AC EATONIA	116,465	1.0%	Y	AAFC
SUPERB	108,543	1.0%	Y	AAFC
WR859 CL	108,492	1.0%	Y	Syngenta
AC BARRIE	100,383	0.9%		AAFC
KANE	85,837	0.8%	Y	AAFC
AC INTREPID	85,553	0.8%	Y	AAFC
AC SPLENDOR	85,122	0.8%		AAFC
AC DOMAIN	83,276	0.7%		AAFC
INFINITY	79,658	0.7%	Y	AAFC
CDC IMAGINE	74,060	0.7%		CDC
WASKADA	66,685	0.6%	Y	AAFC
PRODIGY	61,825	0.5%		SWP
NOT DESIGNATED	407,136	3.6%		
OTHER	893,435	7.9%		
TOTAL	**11,267,269**	**100%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

AAFC varieties account for a majority of durum plantings (as shown in Table A.7).

Table A.7 Canada Western Amber Durum (CWAD) Varieties and Share of Acreage, 2014

CWAD Varieties	Acres	Share	PBR	Developer
STRONGFIELD	1,176,592	45.3%	Y	AAFC
CDC VERONA	442,306	17.0%	Y	CDC
BRIGADE	435,869	16.8%	Y	AAFC
TRANSCEND	232,553	8.9%	Y	AAFC
AC NAVIGATOR	77,134	3.0%	Y	AAFC
KYLE	75,172	2.9%		AAFC
AC AVONLEA	67,962	2.6%	Y	AAFC
ENTERPRISE	47,668	1.8%	Y	AAFC
EUROSTAR	16,421	0.6%	Y	AAFC
OTHERS	28,169	1.1%		
TOTAL	**2,599,846**	**100%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

CPSR is an example of where there are a number of private sector seed varieties compared to the public sector (see Table A.8).

Table A.8 Canada Prairie Spring Red (CPSR) Varieties and Share of Acreage, 2014

CPSR Varieties	Acres	Share	PBR	Developer
AC FOREMOST	362,676	42.8%	Y	AAFC
5700PR	177,946	21.0%	Y	Syngenta
CONQUER	83,987	9.9%	Y	AAFC
AC CRYSTAL	69,283	8.2%	Y	AAFC
SY985	56,648	6.7%	Y	Syngenta
5702PR	52,867	6.2%	Y	Syngenta
5701PR	20,307	2.4%	Y	Syngenta
OSLO	6,439	0.8%		Nickerson American
AC TABER	6,068	0.7%		AAFC
NOT DESIGNATED	3,154	0.4%		
OTHERS	7,731	0.9%		
TOTAL	**847,106**	**100.0%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

CWES is an example of a wheat class with few acres with only registered public varieties (Table A.9) as is CWGP in Table A.10.

Table A.9 Canada Western Extra Strong (CWES) Varieties and Share of Acreage, 2014

CWES Varieties	Acres	Share	PBR	Developer
BLUESKY	198	38.2%	Y	AAFC
CDN BISON	65	12.5%	Y	AAFC
GLENLEA	255	49.2%		U of MB
TOTAL	**518**	**100%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

Table A.10 Canadian Western General Purpose (CWGP) Wheat Varieties and Share of Acreage, 2014

CWGP Varieties	Acres	Share	PBR	Developer
PASTEUR	230,034	57.8%	Yes	Wiersum Plant Breeding
CDC FALCON	120,293	30.2%		CDC
CDC PTARMIGAN	15,933	4.0%		CDC
BROADVIEW	10,866	2.7%	Y	AAFC
CDC NRG003	8,113	2.0%		CDC
ACCIPITER	3,523	0.9%	Y	CDC
PEREGRINE	2,230	0.6%	Y	CDC
CDC CLAIR	1,995	0.5%		CDC
OTHERS	4,777	1.2%		
TOTAL	**397,764**	**100%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

Table A.11 provides comparable information for winter wheat varieties and acreage planted.

Table A.11 Winter Wheat Varieties and Share of Acreage, 2014

CWRW Varieties	Acres	Share	PBR	Developer
FLOURISH	226,593	47.6%	Y	AAFC
CDC BUTEO	136,595	28.7%		CDC
RADIANT	69,780	14.6%	Y	AAFC
MOATS	17,996	3.8%	Y	CDC
AC BELLATRIX	4,339	0.9%		AAFC
MCCLINTOCK	3,817	0.8%	Y	U of M
EMERSON	2,974	0.6%	Y	AAFC
AC READYMADE	2,811	0.6%		AAFC
NOT DESIGNATED	3,375	0.7%		
OTHERS	8,138	1.7%		
TOTAL	**476,418**	**100%**		
CWHWS Varieties	**Acres**	**Share**	**PBR**	**Developer**
AAC ICEBERG	10,100	33.0%	Y	AAFC
SNOWBIRD	7,711	25.2%	Y	AAFC
SNOWSTAR	5,830	19.1%	Y	AAFC
WHITEHAWK	5,460	17.9%		Monsanto/Westbred
NOT SPECIFIED	1,481	4.8%		
TOTAL	**30,582**	**100.0%**		
CWSWS Varieties	**Acres**	**Share**	**PBR**	**Developer**
SADASH	293,071	58.5%	Y	AAFC
AC ANDREW	206,685	41.3%		AAFC
AAC CHIFFON	471	0.1%	Y	AAFC
BHISHAJ	341	0.1%	Y	AAFC
AC REED	145	0.0%		AAFC
TOTAL	**500,713**	**100.0%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides
Note: CWRW = Canada Western Red Winter; CWHWS = Canada Western Hard White Spring; CWSWS = Canada Western Soft White Spring.

Comparable data is provided in Tables A.12 and A.13 for barley. The CDC developed many of the popular barley varieties shown below. The FCDC in Alberta has developed at least six varieties in use for feed and food purposes (Table A.13), with non-designated implying a non-malt variety. The CDC, Sapporo and Prairie Malt jointly own the malting variety CDC Polarstar. As well, Busch has a few varieties in production.

Table A.12 Malting Barley Varieties and Share of Acreage, 2014

Varieties	Acres	Share	PBR	Developer
DESIGNATED VARIETIES				
AC METCALFE	656,250	39.0%	Y	AAFC
CDC COPELAND	505,873	30.1%	Y	CDC
CDC MEREDITH	118,380	7.0%	Y	CDC
NEWDALE	109,460	6.5%	Y	AAFC
LEGACY	71,033	4.2%	Y	Busch
BENTLEY	46,219	2.7%	Y	FCDC
CDC POLARSTAR	32,301	1.9%	Y	CDC/Sapporo/PML
TRADITION	29,251	1.7%	Y	Busch
CELEBRATION	28,367	1.7%	Y	Busch
CDC KINDERSLEY	17,486	1.0%	Y	CDC
OTHER	68,388	4.1%		
TOTAL	**1,683,008**	**100.0%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

Table A.13 Not Designated (Food and Feed) Barley Varieties and Share of Acreage, 2014

Not Designated	Acres	Share	PBR	Developer
XENA	428,107	21.8%		Westbred Monsanto
CDC AUSTENSON	410,216	20.9%	Y	CDC
CHAMPION	341,942	17.4%	Y	Westbred
CONLON	127,563	6.5%		NDSU
CDC COALITION	101,736	5.2%	Y	CDC
CDC COWBOY	83,091	4.2%	Y	CDC
SEEBE	26,986	1.4%		FCDC
PONOKA	25,939	1.3%	Y	FCDC
SUNDRE	22,140	1.1%	Y	FCDC
CDC TREY	19,300	1.0%	Y	CDC
BUSBY	18,472	0.9%	Y	FCDC
CDC THOMPSON	17,567	0.9%		CDC
VIVAR	13,210	0.7%	Y	FCDC
CDC MCGWIRE	12,565	0.6%	Y	CDC
CHIGWELL	11,026	0.6%	Y	FCDC
STANDER	10,055	0.5%		U of MN
CDC DOLLY	9,843	0.5%		CDC
OTHER	280,340	14.3%		
TOTAL	**1,960,098**	**100.0%**		

Source: Canada Grain Commission, "Cereal Varieties, 2014 Insured Commercial Acres" and SK and AB Seed Guides

Annex B - Funding of Variety Development and Value Capture Today

The prior section indicated that a number of organizations are involved in some capacity in wheat and barley variety development. In this section we begin to explore how wheat and barley variety development is funded. Funding can be segmented into sources of funds and use of funds. We begin by focusing on source of funds.

B.1 Funds Collected From Producers

Wheat and barley producers are a source of funds for variety development, with funding based on check-off levies collected by provincial Commissions and the WGRF. The amount of funds received on an annual basis (using 2014 as a reference point) is approximately $20 million for wheat and $4.5 million for barley. These funds are check-offs on marketings and such check-offs are refundable, since they are not mandatory. Table B.1 below indicates current check-off rates per tonne of grain marketed. The table also indicates the funds collected by organization, with the WGRF receiving the most funds followed by the Saskatchewan and Alberta Wheat Commissions.

Table B.1 Producer Funds Collected Through Refundable Check-Off Levies, 2014[12]

Producer Organization	Check -Off Levy		Funds Collected		Variety Development Spend	
	Wheat	Barley	Wheat	Barley	Wheat	Barley
	$/t	*$/t*	*$ million*	*$ million*	*$ million*	*$ million*
BC Peace River Grain Industry Development Council	$0.48	$0.56				
Alberta Wheat Commission	$0.70		$5.7		$0.5	
Alberta Barley		$1.00		$2.7		$0.4
Saskatchewan Wheat Development Commission	$0.52		$6.0			
Saskatchewan Barley Development Commission		$0.50		$0.8		
Saskatchewan Winter Cereals Development Commission	$0.50		$0.1			
Winter Cereals Manitoba Inc.	$0.50		$0.1			
Manitoba Wheat & Barley Growers Association	$0.52	$0.50	$0.7	$0.1	$0.6	
Western Grain Research Foundation	$0.48	$0.56	$7.7	$0.9	$5.1	$1.0
Totals			**$20.3**	**$4.5**	**$6.2**	**$1.4**

Source: Tabulations based on data provided by Working Group members.

These producer dollars are used to fund a number of initiatives, with variety development being only one of them. Evidence that we have been able to assemble indicates that possibly $6.2 million of these producer funds were directed towards variety development of wheat and $1.4 for barley over the last year. The majority of these expenditures were by the WGRF.

[12] The values in Table B.1 are for 2014 (a combination of crop years and fiscal years) and may not represent average values. For example the expected 5 year average for AWC is $4.8 million. Many organizations have been collecting funds for less than 3 years. The WGRF check-off rate for Barley in Alberta is much lower at $0.04/tonne.

B.2 Funds Used For Variety Development

Estimates have been made on the annual flow of funds supporting variety development for wheat and barley. DePauw[13] estimated that approximately $30 million is expended on wheat variety development, with AAFC the largest contributor of funds at $14 million, followed by NRC funding of $13 million and approximately $5 million from producer sources (mostly via WGRF). This estimate does not seem to account for provincial government spending or private investment (unless it is commingled with government and NRC funding), with CSTA indicating $6.2 million expended on wheat and $1.7 million on barley (in 2013).

Anecdotal information suggests that a cereal breeding program headed by one plant breeder has annual operating costs of over $1.0 million and likely closer to $1.5 to $2.0 million. Using a mid-point value of $1.5 million, this suggests with 15 public wheat breeders, then at least $22.5 million is expended on the breeding and finishing of wheat varieties, before considering costs associated with discovery research, such as at NRC. Similarly, with 5 public barley breeders, annual investments in breeding could be in the range of $7.5 to $10 million. A breeding program with two breeders likely requires approximately $3.0 to $4.0 million for annual operating costs, plus the necessary capital for the supporting infrastructure of a breeding program.

Table B.2 provides an estimate of spending on variety development by crop kind. This table attempts to provide the best indicative data on public, private[14] and producer funding of variety development. Information from this table can also be used to indicate how Canada is performing on variety development investments in relation to other countries. For wheat and barley, total investment in variety development is estimated to be $56 million, with the public sector the largest investor at $40.5 million (72% of the total).

Table B.2 Spending on Variety Development, by Crop Kind

Item	Units	Wheat	Barley	Canola	Corn	Soybeans
Expenditures on Variety Development	*$ million*	**$46.1**	**$10.0**	**$64.8**	**$16.5**	**$9.6**
Private (Via CSTA)	*$ million*	$6.2	$1.7	$64.8	$16.5	$9.6
Producer	*$ million*	$6.2	$1.4			
Public (Government and Universities)	*$ million*	$33.7	$6.9			
Farm cash receipts (2013 & 2014 average)	*$ million*	$5,628	$684	$7,635	$2,231	$2,337
Expenditures per 1$ of cash receipts	*%*	0.8%	1.5%	0.8%	0.7%	0.4%
Acreage (2013 to 2015 average)	*million acres*	22.6	6.4	20.3	3.4	4.5
Expenditures/acre	*$/acre*	$2.04	$1.57	$3.19	$4.89	$2.10
Production (2011 to 2014 average)	*million tonnes*	27.5	7.8	15.5	12.5	5.2
Expenditure/tonne of output	*$/tonne*	$1.67	$1.27	$4.18	$1.32	$1.83
Seed purchases (sales by seed companies)	*$ million*	$181	$51	$1,219	$371	$364
Expenditures per $1 of Seed Sales (purchases)	*%*	25.5%	19.6%	5.3%	4.4%	2.6%
Seed purchases as a % of cash receipts	*%*	3.2%	7.4%	16.0%	16.6%	15.6%

Sources: CSTA, DePauw, and information provided by WGRF and wheat and barley Commissions.

Based on the information complied, variety development spending ranges from 0.4% to 1.0% of farm cash receipts[15], with barley the largest at 1.5% and wheat at 0.8%. Canola has the largest private sector funding at $64.8 million, and is 0.8% of farm cash receipts, which is prior to accounting for any public or producer funding. On a per acre of production basis, corn is the largest at $4.90/acre of corn planted across Canada based on only private sector investments. Using an

[13] Source: DePauw, "The Challenges of Plant Breeding: From Cultivar to Commercialization", 2014.
[14] Based on the 2012 CSTA survey.
[15] For wheat and barley farm cash receipts and acreage are only for western Canada.

estimated value of certified seed purchases from seed companies[16] has overall spending on variety development ranging between 15% and 17% of seed sales for canola, corn and soybeans, and between 3% and 7% for wheat and barley (see last row in Table B.2)[17].

Table B.2 provides an annual view of the flow of funds. Many granting agencies provide funding commitments that cover a number of years. Examples include:

- Canadian Wheat Alliance (CWA) has $97 M. over 5 years, which is based on funds provided by AAFC, U of S, the Government of Saskatchewan, NRC, and producer funding.
- National Wheat Improvement Program (NWIP) (or the Wheat Cluster) has $25.2 M. for the 2013-2018 period, with funding provided by WGRF; CFCRA, AWC, and AAFC; and
- National Barley Cluster.

Some changes have occurred in funding of variety development over the last decade or so. First, the level of expenditures on overall R&D conducted within AAFC and supported by AAFC has decreased over the last 5 years[18]. At the same time that A-Base funding has declined, a larger portion of public funds that support variety development are taking the form of 5-year funding commitments. In many areas of variety development, such as the pre-breeding discovery research, longer time horizons are required to bring forward results that can be commercialized.

Another change is the trend way from a reliance on mostly public funding to co-funding through partnerships. A number of these were highlighted in the prior section. More co-funding through partnerships can be expected over the coming decade.

B.3 Funds Used For Variety Development by Stage of Variety Development

Some researchers have suggested that the majority of spending should be on discovery type effort (of over 50%) followed by an even split of funds on the remaining pre-breeding activities and the breeding activity. At the same time, preliminary information we have assembled indicates that approximately 20% of actual expenditures are on variety finishing and the remainder evenly split between breeding and pre-breeding.

An attempt is being made to reach out to the major research institutions (AAFC, FCDC, NRC, U of S (CDC), U of M, U of A, and WFGDC) to capture indicative information on the allocation of variety development research funds by stage of variety development. This information is in the process of being compiled. Some institutions may be hesitant to, or unable to, offer such a breakdown of annual spending.

B.4 Expected Trends in Funding and Variety Development Focus

There are some general trends to consider. AAFC will likely have a much different role in variety development, with minimal effort on variety finishing, with the private sector picking up more of this lower cost component of variety development. AAFC may also continue the trend away from A-Base funding of career research programs toward networked project based funding. AAFC funding levels for variety development are also surrounded by some uncertainty.

[16] $/acre for certified seed used in the table are $40/acre for wheat, $40/acre for barley, $60/acre for canola, 110$/acre for corn and $80/acre for soybeans, with 20% of corn and barley acres using certified seed.
[17] These values may change as more defensible data is made available.
[18] See Morgan Jones, S.D. *White Paper on Research Innovation in Cereals*, (see Table 1).

Governments have increasingly moved toward project based funding such as the CWA, NWIP and Genome Canada. While this move focuses research and provides greater accountability, it also creates additional issues for attracting career scientists and maintaining infrastructure. Such projects also require additional transactions costs associated with proposal writing, project selection and project management.

The reduction in research and breeding conducted at regional stations has geographically focused the breeding effort to the locations where breeders are active.

At Alberta Agriculture and Rural Development (AARD) current funding is stable but insufficient. There is more interest in genomics than previously. Many private sector companies now appear to be interested in wheat variety development partnerships[19].

The Province of Alberta is facing some funding issues for programs in the future creating uncertainty for AARD's programing in variety development (currently the Government of Alberta provides $3 M. to FCDC at Lacombe). If dollars are reduced then staff will have to be cut which will reduce AARD's research capacity. The WGRF has a Wheat Breeding Agreement with AARD to provide core funding. Private sector companies have been speaking to AARD about collaboration/partnership/investment. However, AARD's major challenge is it does not have freedom to operate as it is not set up for partnerships[20].

At the U of M, stable funding is very important. Short term funding (as is popular now) does not accommodate the needs and requirements of a long-term breeding program.

Networks and clusters are becoming more prevalent, with co-funding of variety development initiatives. The Canadian Wheat Alliance with funding from AAFC, the U of S, the province of Saskatchewan, the NRC, producer funding, and the private sector contributions, being such an example.

The creation of wheat and barley Commissions in each province is also a rather new development with the resulting revenue stream that can be used in part to fund variety development. However, it can be argued that these funds could be centralized for a more effective leveraging of these producer dollars. Doing so would be a substantive move away from the provincial and farmer directed accountability for the levy funds.

A game changer for variety development is UPOV 91 confirmation earlier this year, which provides the legal basis for developing an EPR system that can fund varietal development, and more importantly, create incentives for more investment in varietal development by private sector seed companies.

B.5 Value Capture Today by Participants in Variety Development

Public sector plant breeders such as AAFC and universities protect their intellectual property (IP). For instance, crop varieties are typically registered under Plant Breeders Rights and these rights are held by the institution. The protected varieties are then commercialized with an obligation for seed growers to remit seed royalties. Seed companies bid on variety tenders, and if successful, share a portion of the royalties collected on their sales of certified seed. It should be noted that the royalties

[19] Personal communication with Mark MacNaughton, Director of Field Crops Branch, AARD and Director of FCDC.

[20] In this report we will refer to P3 and P4 partnerships. P4 refers to Producer-Public-Private Partnership and a P3 refers to either a Producer-Private Partnership or a Producer-Public Partnership.

collected on AAFC varieties flow to general revenues of the government of Canada and do not directly flow back to support breeding programs.

At the FCDC in Alberta, royalties are captured on barley varieties developed at FCDC. The royalty revenues flow to the ACDIF, for re-investment into variety development.

With producer based organizations, only the WGRF and the AWC currently have some method of value capture. Recently AWC and WGRF have negotiated agreements where they receive a portion of the royalties from the breeding programs they invest in. The WGRF has some long-term agreements with AAFC and CDC which will provide a percentage of royalties. AWC will soon announce a 4-P partnership where royalties will be received on lines developed out of a particular breeding program.

Private seed companies capture the value created by their breeding efforts only on certified seed sales. Farmer-saved seed is not subject to royalties at this time.

The Clearfield technology and system is another value capture system used by the private sector. Clearfield is a production system developed by BASF based on an herbicide-tolerant trait in certain crop kinds such as wheat, canola, sunflowers and lentils. The technology is based on crossing an herbicide tolerant plant with other parental lines using conventional plant breeding methods, which results in the variety not being classified as a GM plant. As well, the plant is a non-hybrid. The value capture by BASF is through licensing agreements not to reuse the resulting seed (i.e., need to buy certified seed each year) and/or by producers purchasing BASF crop protection materials. In the case of Clearfield wheat in the US, producers are prohibited from using FSS and are subject to at least $100/acre penalties for using farmer-saved Clearfield seed. In other cases, such as brown-bagging of lentils for subsequent use (use of FSS) is encouraged, since the value is captured through the use of BASF herbicides.

Comparable technologies and use agreements can be used for new wheat and barley varieties as a value capture method by owners/distributors of new varieties. Seed license agreements could also include per acre payments for FSS. In this way, such technologies/use agreements are a direct substitute for an EPR system, and opportunities exist to capture the value inherent in the associated farmer-saved seed.

Annex C - Factors Affecting Wheat and Barley Variety Development

There is a very compelling case for more investment in wheat and barley variety development. First, there is the argument for greater investment. Growing world populations' higher income and dwindling natural resources speak to the need to continue to improve productivity as a means of addressing global food security. Second, a comparison of research funding levels suggests that not only have wheat and barley breeding expenditures decreased over time, but that competing crops within Canada, and wheat sectors in other countries, are spending more resources than is being invested in Canadian wheat and barley[21]. Third, an examination of the share of the area planted to wheat and barley in Western Canada shows a dramatic decline over time, indicating that other crops have become relatively more competitive over the past 30 years[22].

Finally, perhaps the most compelling reason is that numerous studies have shown high rates of return to investment in wheat and barley research, suggesting that there is an opportunity to increase the well-being of grain producers and the sector as a whole through additional investments in breeding activities. The 20 to 1 benefit to cost ratio reported for WGRF wheat research indicates that for every producer dollar not invested in wheat breeding, the sector forgoes $20 in future returns[23]. This creates an incentive for more plant breeding activity whether by the public, private or producer sectors. However, as discussed in this report, the private incentive is linked to the private investor being able to capture a portion of the benefits – the value capture.

C.1 Wheat and Barley Being Competitive With other Crop Kinds

Over the last two decades, acreage planted to wheat and barley in western Canada has declined by approximately 8 million acres, while area planted to canola, corn, peas, lentils and soybeans has increased. Canola acreage expanded by 6.2 million acres, a 2.9% annual increase. As reported in Table C.1, barley acreage decreased by 4.0 million acres (based on comparing the 2008 to 2014 average to the 1994 to 2000 average); an annual decrease of 3.2% in area planted. In wheat, winter wheat acreage increased by 0.7 million acres, while spring wheat declined by 4.3 million acres, a 1.6% annual decrease.

The trend in acreage planted for wheat, barley, canola and hay in the three prairie provinces each year since 1981 is also illustrated in Figure C.1.

Relative Growth in Yields Affects Acreage Planted

A number of factors help explain the acreage shift. One factor is the growth in per acre yield among competing crop kinds. The data in Table C.2 indicate that yield growth has been more prominent for some crop kinds than for others in western Canada. For example, canola yields have grown by 2.4%, or by 9.6 bu/acre, over the two periods (of 2008-2014 in relation to 1994-2000 average). This growth rate has been more pronounced for wheat than for barley, which was a 0.7% annual growth, compared to 1.8% for spring wheat. These average increases in yields can explain a large part of the shifts in crop acreage; however, there are other factors that need to be considered.

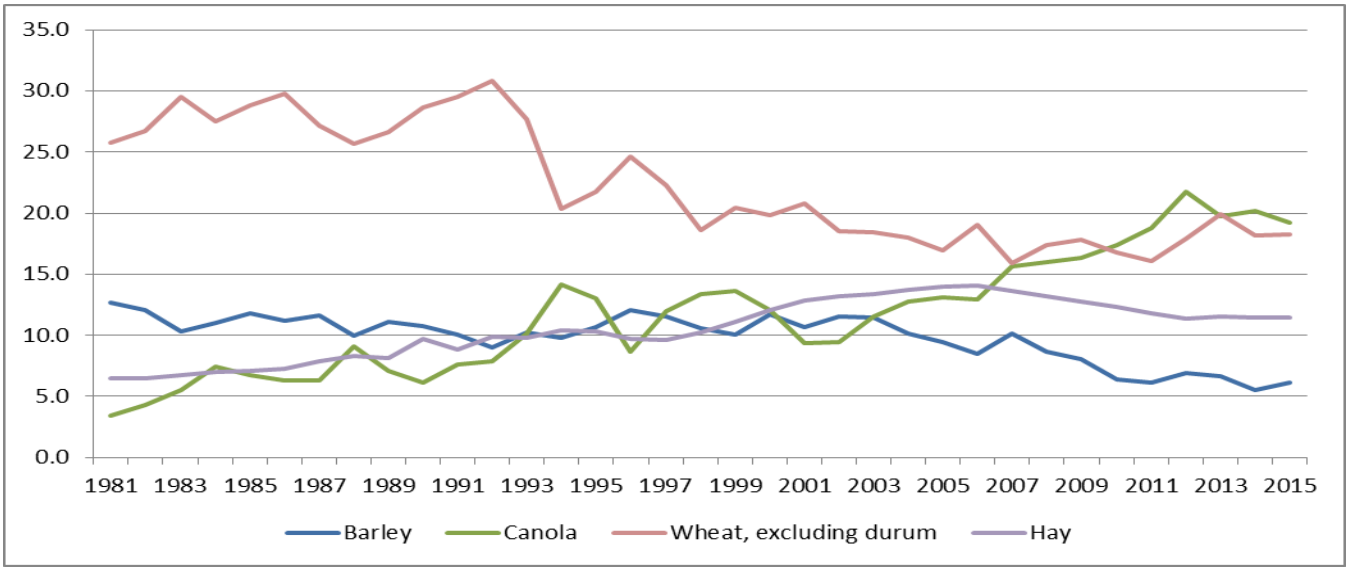
[21] Fuglie, Keith, et al. "*Research Investments and Market Structure in the Food Processing, Agricultural Input, and Biofuel Industries Worldwide*." USDA-ERS Economic Research Report 130 (2011).
[22] Terrence S. Veeman and Richard Gray, "*The Shifting Patterns of Agricultural Production and Productivity in Canada*" in The Shifting Patterns of Agricultural Production and Productivity Worldwide. The Midwest Agribusiness Trade Research and Information Center, Iowa State University, Ames, Iowa (2000).
[23] Richard Gray, Cecil Nagy, and Alper Guzel, "*Returns to Research; Western Grains Research Foundation Wheat and Barley Varietal Development*" prepared for the Western Grains Research Foundation (October 2012).

Table C.1 Changes in Prairie Acreage by Crop Kind, 1994-2000 to 2008-2014 averages

Crop Kind	Average Acreage 1994 - 2000	Average Acreage 2008 - 2014	Acreage Change	Annual Change
	million acres	*million acres*	*million acres*	*%*
Barley	10.9	6.9	-4.0	-3.2%
Canola	12.4	18.6	6.2	2.9%
Chick peas	0.2	0.2	0.0	-0.7%
Corn for grain	0.1	0.3	0.2	7.7%
Flaxseed	1.9	1.2	-0.7	-3.1%
Lentils	1.0	2.6	1.6	6.8%
Oats	4.2	2.9	-1.3	-2.7%
Peas, dry	2.1	3.5	1.4	3.6%
Soybeans		0.9		
Wheat, durum	5.7	4.7	-1.0	-1.3%
Wheat, spring	20.9	16.6	-4.3	-1.6%
Wheat, winter	0.2	0.9	0.7	11.5%
Wheat, excluding durum	21.1	17.7	-3.4	-1.2%
Tame hay	10.5	12.1	1.6	1.0%
Total of Above	**70.1**	**71.3**	**1.2**	**0.1%**

Source: Statistics Canada. Table 001-0017 - Estimated areas, yield, production, of principal field crops, in imperial units, annual, CANSIM (database). (accessed: 2015-06-23)

Figure C.1 Trend in Large Acreage Crop Plantings, Prairies, 1981 to 2015 *(M. acres)*



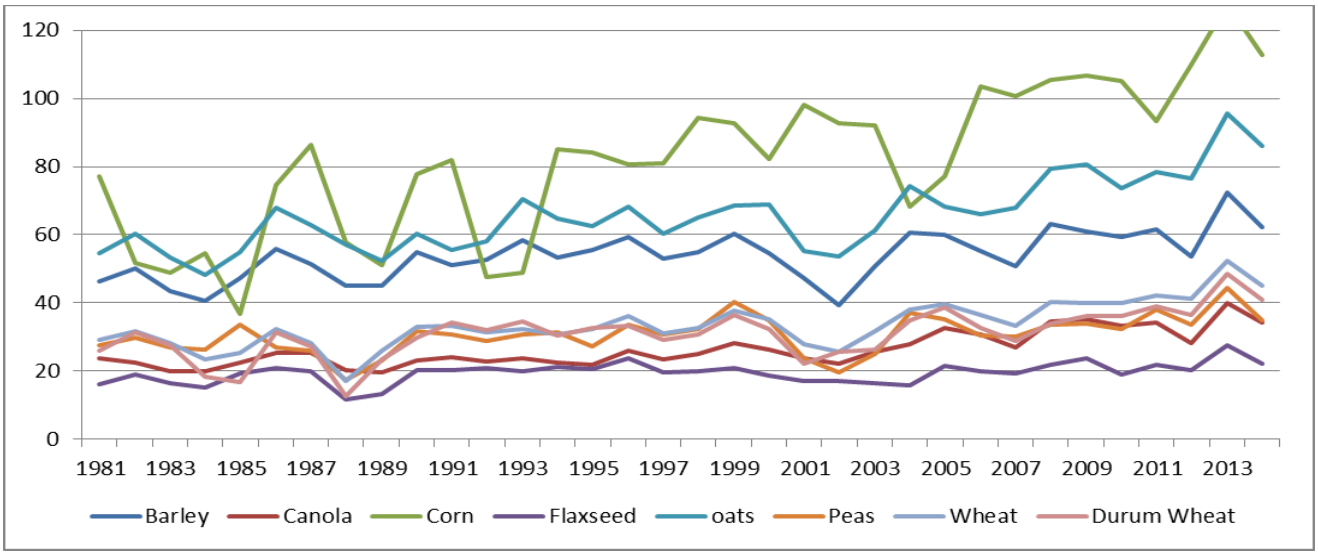
The yields shown in Table C.2 and Figure C.2 are an average on-farm outcome, which does not hold constant the area weighted average yield in a specific region when acreage planted shifts. For example, canola with an average yield gain of 6.2 bushels per acre occurred as canola acreage moved to areas not traditionally planted in canola; and as a result the actual gain due to canola plant breeding is likely understated for traditional canola growing areas. Similarly, wheat acreage has declined and has been retreating to more traditional prime wheat growing areas, which can overstate the yield gain of 9.7 bu/acre compared to having the total wheat area planted held constant.

Table C.2 Growth in Average Yields by Crop Kind, 1994-2000 to 2008-2014 averages

Crop Kind	Average yield		Yield Increase	Annual Growth
	1994 - 2000	2008 - 2014		
	bu/acre	*bu/acre*	*bu/acre*	*%*
Barley	55.9	61.9	6.0	0.7%
Canola	24.7	34.3	9.6	2.4%
Corn for grain	85.7	108.7	23.1	1.7%
Flaxseed	20.7	22.4	1.7	0.6%
Oats	65.5	81.5	16.1	1.6%
Peas, dry	32.9	35.8	2.9	0.6%
Soybeans		32.1		
Wheat, durum	32.2	38.7	6.5	1.3%
Wheat, spring	34.0	43.7	9.7	1.8%
Wheat, winter	40.4	53.2	12.8	2.0%
Wheat, excluding durum	34.0	44.2	10.1	1.9%

Source: Statistics Canada. Table 001-0017 - Estimated areas, yield, production, of principal field crops, in imperial units, annual, CANSIM (database). (accessed: 2015-06-23)

Figure C.2 Trend in Yields by Crop Kind, Prairies, 1981 to 2015 *(bu/acre)*



Variety trails at specific research station locations are a better indicator of variety improvement. Veeman and Gray[24] noted that over the 1960 to 2007 period, average farm level crop yields increased by 60% (in total and 1.0% per annum), and increases in wheat yields were similar to other major field crops[25]. However, at the same time experimental trial (at specific research stations) yields for wheat increased by just over 120% and by 160% for canola, or an annual growth rate of 1.7% and 2.1%, respectively. This difference between farm level yield growth and

[24] Terrence S. Veeman and Richard Gray, "*The Shifting Patterns of Agricultural Production and Productivity in Canada*" in *The Shifting Patterns of Agricultural Production and Productivity Worldwide*. The Midwest Agribusiness Trade Research and Information Center, Iowa State University, Ames, Iowa (2000).

[25] The lower on-farm yield growth using the 1960 to 2007 time frame of 1% compared to 1.8% as reported in Table 4.2 is consistent with other studies that indicate yield growth since the early 1990's was much higher than in the period prior to the 1990's.

experimental plot yields could be attributed to changes in area seeded and disease pressures. For example, as canola acres migrate into other areas, this can lower the average farm yield, and as wheat acreage retreats to traditional wheat areas, this can result in a higher average farm level yield compared to the average farm yield if wheat acres remained constant.

In a recent journal article, two AAFC researchers (Thomas and Graf[26]) indicated that on-farm wheat yields in western Canada increased by ~ 1.4% since 1991, which compared favorably to a 1.16% world-wide increase as measured by FAO. Over this same time period (1991 – 2012), yield increases based on release of new wheat varieties showed an increase of 0.67% using data from Manitoba and Saskatchewan Seed Guides. These study results can be used to infer that agronomic practices were a contributing factor to the higher on-farm yields realized over the same time period – since on-farm gains outpaced those based on releases of new varieties, where presumably the agronomic package is held relatively constant. Continued increases in yield gain are required, and realizing yield increases while increasing net returns per acre will help keep acres in wheat and barley production.

These yield increases based on new variety releases were double of these estimated for the earlier period of 1952 to 1990 period. Thomas and Graf did note that these higher yield increase were being realized at the same time as WGRF funding (based on producer check-offs) of variety development at AAFC occurred. Such funding paid for hardware (e.g., seeders), consumables (e.g., herbicides), growth facilities (e.g., winter nurseries), and additional technical staff. This study affirms the importance of gains in wheat and barley varieties.

Accounting for All Inputs Used to Produce a Crop Using Multi-Factor Productivity Measures

Per acre yields are a simple measure of output for one major input, being land. This measure does not account for the other inputs that are required to produce the crop (e.g., crop protection materials, fertilizer, equipment, etc.). The total factor productivity measure accounts for the use of all inputs needed to produce a crop. Veeman and Gray provided such a measure for all prairie crops over the 1940 to 2004 period and for the 1990 to 2004 period. There was a dramatic decrease in this productivity measure, from 1.77% annual compound growth over the 1940 to 2004 period, which declined to only 0.51% in the 1990 to 2004 period. This is an indication of the necessity to use more inputs to deliver annual increases in output. To address this situation, improvements in variety development can offset the need to apply more inputs and thereby increase the relative profitability of crop production.

In a recent Master's thesis, Liyang Huang[27] used a multi-factor productivity approach to show overall productivity gains for wheat versus canola in Saskatchewan over the 1993 to 2013 period. Over this period, canola's productivity factor increased by 140% in the dark brown zone versus spring wheat at approximately 70%. An interesting feature was that productivity growth was rather comparable for wheat and canola until the 2004 to 2005 period; and thereafter canola productivity continued to advance while wheat's overall productivity stalled, with only a modest increase. Across the province the total productivity for wheat was just over 2.5% per annum while for canola this stood at 4%. If canola's overall productivity growth rate exceeds the measured yield increase, this simply implies that fewer inputs were required to achieve the yield gain. Part of this gain could be attributed to varietal development and the need for fewer operating inputs with specific varieties.

[26] Julian Thomas and Robert Graf, "*Rates of yield gain of hard red spring wheat in western Canada*", Can J. Plant Sci. (2014) 94: 1-13 doi:10.4141/CJPS2013-160

[27] Liyang Huang, "*Multi-factor Productivity Growth in Saskatchewan Crops*", Master's Thesis, University of Saskatchewan (2014).

Net Returns Per Acre Can Influence Acreage Planted

Net return per acre is a major factor affecting shifts in crop acreage. These returns are influenced by yield and market prices on the revenue side and by operating costs on the input side. Advances in yields can help offset market place returns for a crop that is not keeping up with other crops (such as wheat vs canola). A measure of potential per acre returns for wheat and canola in Saskatchewan, after accounting for operating costs, is shown in Table C.3 for 2015 by soil zone and indicates that winter wheat and malt barley were projected to provide a higher return per acre in the brown soil zone; with canola and malt barley providing higher projected returns in the dark brown and black soil zones. Wheat and feed barley provided a better projected return than canola in the brown soil zone. Canola provided a better return per acre projection than spring wheat in the dark brown and black soil zones for 2015. Obviously higher prices and higher yields for wheat and barley can change the projection and resulting cropping patterns

Table C.3 Projected Returns Over Operating Costs, Saskatchewan, 2015

Item	Units	Spring Wheat	Durum Wheat	Winter Wheat	Malt Barley	Feed Barley	Corn	Soybeans	Canola
Plannng Price	*$/bu*	$6.11	$6.12	$5.25	$4.50	$3.46	$3.75	$10.07	$9.48
Planning Yield									
Brown Soil	*bu/acre*	30.0	34.7	38.8	47.2	56.6	75.0	25.0	27.7
Dark Brown Soil	*bu/acre*	42.0	43.1	51.0	61.9	68.1	85.0	30.0	36.3
Black Soil	*bu/acre*	46.9		54.8	67.9	74.7	100.0	30.0	36.6
Returns over Operating Costs									
Brown Soil	*$/acre*	$61	**$74**	$72	**$91**	$71	$54	$86	$67
Dark Brown Soil	*$/acre*	$108	$101	$115	**$135**	$92	$52	$98	**$126**
Black Soil	*$/acre*	$119		$114	**$150**	$102	$78	$90	**$126**

Source: Government of Saskatchewan, "*Crop Planning Guide 2015"*

Other factors that affect acreage shifts include the availability of other crops such as peas, lentils for rotation and maintenance of soil fertility.

The data does indicate that wheat and barley are losing share in planted acreage in western Canada to other crop kinds, such as canola and potentially other crops in the near future, such as soybeans and corn. The data also indicate that overall productivity of wheat and barley is a contributing factor to this shift, and that variety development that results in higher yields or lower input costs can assist in wheat and barley remaining as dominant crops planted in western Canada.

C.2 Current Incentives (New Act and EPR)

Recently there have been three major changes in Canada that may partially address the research funding gap. The establishment of several new cereal commissions in Western Canada was also accompanied with an increase in the check-off level in most cases, bringing the total check-off rate to approximately $1.00 per tonne, up from $0.30 per tonne in the case of wheat (refer back to Table B.2 in Annex B). This larger pool of producer directed money also provides additional scope for producer investment and control in breeding activities.

Second, there is some realignment in agricultural research funding occurring at the federal level which is becoming more focused on wheat genomics and pre-breeding activities. This is taking place through Growing Forward 2 research clusters, the NRC led Wheat Flagship Project, and

Genome Canada investments including the Canadian Triticum Advancement Through Genomics (CTAG). Producer funding also supports these initiatives.

Third, the February 2015 passage of the *Agricultural Growth Act*, creates stronger intellectual property rights and brings Canada in alignment with the provisions of UPOV 91. This Act creates the foundation for the establishment of contract based end point royalties (EPRs) and includes other provisions that will enhance a cereal breeder's ability to earn royalty income. In combination with actions of government and producer funded organizations, the Act may help attract additional private investment in wheat and barley breeding activities.

Where breeders choose to continue to use certified seed for royalty collection, the *Agricultural Growth Act* will provide greater control over the "brown-bag" seed market[28], increasing the demand for commercial seed. Notably, the Act extends the breeders rights to harvested material of an unauthorized use of a variety. This provision facilitates the enforcement of seed bag license agreements, which is the mechanism used by breeders in Australia to create an EPR system. Similar to the Microsoft Software agreement, the act of opening a bag of seed by a producer constitutes an agreement to the terms of the licensing agreement, which obligates the producer to pay an EPR on the sales of their harvested material of any variety.

The federal government has proposed changes to Canadian wheat classes. If the proposed changes are made and an additional spring wheat class is developed, it will allow the registration of varieties that previously would not have fit into CWRS or CPSR (as well as covering unregistered US varieties). The new class requirements would be much easier to meet. This would be especially beneficial to private sector breeders needing to show their investors success quickly and would allow quicker licensing of existing US varieties.

C.3 Current Barriers and Disincentives to Variety Development

The public sector has had a long history of investment in agricultural research and breeding and continues to recognize the importance of these investments. Despite this recognition, public investment has been insufficient to capture all of potential benefits from breeding. In the past number of years we have seen a decline in breeding activities as governments allocate scarce taxpayer dollars to other higher priority activities. For example, Morgan Jones has estimated that AAFC's science and technology branch had a salary and operating budget of $307 million in FY 2011/12, which declined to $251 million[29] in FY 2014/15. In this period, the number of breeders declined as expenditures on salaries decreased, and industry sources indicate that breeding lines also decreased. Given the long term decline in these activities, sustained re-investment within the public sector seems unlikely.

When compared to spending on varietal development in other jurisdictions, the apparent underinvestment in wheat and barley activities begs the important question of why such underinvestment has persisted, and potentially become larger. The answer becomes more apparent when looking at specific funding sources. Over the longer-term, governments and taxpayers in general have reallocated expenditures away from cereal research as new priorities and agricultural research have risen, and as healthcare and other broader priorities have moved resources away from the sector.

[28] Brown-bag seed is seed that is saved by farmers for planting the next crop, and is generally all seed aside from certified seed

[29] Morgan Jones, S.D. White Paper on Research Innovation in Cereals, (see Table 1).

Producers fund agricultural and cereal research through check-off programs. While these resources have been important for cereal research, the level of the refundable check-offs are likely considered insufficient to provide a sustainable funding model for cereal breeding.

Finally, the private sector has played a very limited role in wheat and barley breeding given the farmers' ability to use royalty free farm saved seed and replant elite varieties. That is, private investors in variety development have limited opportunity to capture some of the value created to justify their investments. In addition, unlike corn and canola, hybridization of wheat and barley does not, as of today, provide sufficient heterosis to justify using hybrid wheat as a value capture mechanism. Taken as a whole, the limitation on each funding source has contributed to a consistent lack of resources for funding wheat and barley breeding Western Canada.

C.4 Gaps and Bottlenecks that Should be Addressed

The current system is far from achieving the goal of a well-funded, well-governed, wheat and barley variety development system. Underinvestment today will also reduce the capacity of the system (i.e., number of plant breeders) in the future. There are several critical gaps that need to be addressed going forward.

Providing an adequate level of basic research is a concern. As governments have increasingly moved towards applied research, they have also shortened the timeline for knowledge deployment. For instance, in a recent Genome Canada project call, there is an expectation that the main impacts of the research occur within five years of project completion, when some project may require up to 10 years to realize findings that can be developed into plant varieties. These types of expectations increasingly move the research away from pure discovery-based basic research toward applied research. In the long run, the absence of the discovery research may significantly impede genetic progress.

While the creation of new cereal Commissions in Western Canada is a welcome addition to the wheat and barley research funding picture; several challenges remain. First of all, the large number Commissions and related organizations create a challenge for the coordination of activities, making it very difficult to avoid duplication of research activities. Second, these Commissions that are established under provincial legislation all have a refundable levy structure, which creates a potential free-rider problem that limits the level of the levy rate that can be charged. Finally, in the case of barley, the large portion of feed use, and associated farm to farm sales, makes it more difficult to collect the check-offs due on production, further reducing the levy resources available for investment.

Producers have been involved in funding variety development for the past twenty years. The potential for even greater producer funding of wheat research is limited by the refundable nature of the existing check-off funding mechanisms. While refundability provides great accountability of these organizations, the public good aspects of the output also creates the incentive for some producers to ask for refunds and free ride on the benefits created. This incentive that increases as check-off levels increase. While producers currently play a significant role in funding cereal variety development, growth in funding intensity will be limited by the refundable nature of the check-offs.

To date, the private sector has had a limited role in wheat and barley breeding in Canada, as well as in many parts of the world. This lack of significant investment is directly attributable to the weakness of intellectual property rights and the corresponding inability to capture a private return to cereal breeding. As mentioned previously, the farmers' ability to retain royalty free saved seed undermines the ability to earn significant returns from breeding and commercializing new varieties. Notably, there has been some private investment, based on commercializing public varieties,

sharing germplasm, some use agreements (e.g., Clearfield), and investing in hybrid and GM platforms with stronger property rights. However, significant autonomous private investment will not occur without an ability to capture a larger portion of the returns embodied in new varieties.

Even with the passage of the *Agricultural Growth Act*, the ability to generate additional royalties with the stronger Plant Breeders Rights could be severely constrained for many years to come. If no further regulatory action is taken, breeders will not only have to develop contract based EPR, but will have to compete with free varieties for decades to come. In Australia, similar legislation was passed in 1994. It took the industry until 2010 to achieve EPR rates sufficient to fund basic breeding programs. Australia now has $50 million per annum in wheat royalties. The reasons cited for the long delay were:

- the predominance of existing free wheat varieties that were in the market place at the time of introduction;
- the time needed to create and establish an administrative system for effective royalty collection;
- the time needed to gain acceptance by producers and grain marketers to accept the use of different forms of contribution; and
- the time needed to create varieties that generate higher profits per acre for grain farmers.

If a similar trajectory is followed in Canada, it would take until 2031 to establish a viable private breeding industry. An alternative system of a uniform technology fee paid back to breeders, similar to that employed in France, may be needed to address this gap. In France, a uniform EPR applied to all varieties (a universal EPR), irrespective of the date of introduction, provides a larger royalty stream to developers.

The inability to create private partnerships may impede private participation in cereal breeding in Canada. Private partnerships with large multinational firms have been used in many countries to gain access to the proprietary breeding technologies in exchange for grant access to valuable domestic germplasm. Thus far, private sector partnerships have been small and limited to universities, who control their germplasm. The CDC has a number of partnerships with private sector seed companies in wheat and barley breeding and producers groups (e.g., pulses). More partnerships are expected in variety development in the near future between producers, the private sector and the public (government and universities),

Governments are reluctant to establish exclusive partnerships. At the current time, wheat and barley breeding is dominated by AAFC. The CDC at the University of Saskatchewan also has a significant role in plant breeding, and has entered into exclusive partnerships. Without some ability for public breeding institutions to collect royalty revenue, and enough autonomy to form partnerships[30], it is unclear how partnerships can be created. Similarly, producer check-off organizations lack the mechanisms to create partnerships and do not control any of the germplasm in the programs they have invested in. This combination makes it more difficult for these organizations to create or participate in partnerships. New ownership and governance models may be required.

Having some certainty of roles of various institutions in variety development is important to the wheat and barley sectors. The 2013 announcement of the intent to get AAFC out of variety release by the Minister of Agriculture, that was subsequently rescinded, suggests that future similar moves in Canada cannot be ruled out. Strategies may need to be developed to account for such potential outcomes.

[30] We have been told that the number one gap is the license to operate. Public organizations like FCDC have little freedom to partner with others and to receive investment from the private sector.

There are gaps in the output of current wheat and barley varietal development programs. Winter wheat, bio-industrial wheat, and general purpose wheat appear to require better varieties. There are also specific geographical needs for more appropriate wheat and barley varieties for Northern and Central Alberta.

C.5 Need for Producer Involvement in Variety Development

Producers are beneficiaries of variety development when new varieties improve returns per acre planted, and have necessary self-interest to be involved (e.g., funding) in variety development. The need for greater producer involvement in wheat breeding also comes from experience in other crops and other countries that have demonstrated that public breeding systems can be vulnerable to policy choices that cut resources and transfer vital germplasm to private breeders. The experience in UK wheat breeding provides a salient example of a privatization failure.

The Plant Breeding Institute (PBI) located at the University Cambridge was a very successful public wheat breeding institution with a self-funded 80% market share in the UK, and widely recognized global leader in green revolution wheat genetics. During privatization, the breeding component of PBI was sold to Unilever, which was subsequently sold to Monsanto and then sold by Monsanto to RAGT in 2004. The result was a private industry with insufficient royalty income, which supported six small private breeding programs. To make matters worse, many pubic upstream researchers abandoned wheat pre-breeding research, to pursue more publishable “model” crop research. Five years after the sale of PBI, the wheat yield increases in the UK stalled and the UK lost its leadership role in wheat research.

To date in Canada there has been a long history of public research institutions, governments, producer research organizations and private seed producers communicating, working together and creating institutions to maximize the benefit created from scarce breeding and research dollars. When a high priority need is identified, producer or public resources are typically redeployed to address the issue. Recent examples, of such cooperation would be the establishment of the wheat research cluster or the recent initiative of WGRF to fund agronomic research. Given this ongoing priority setting, redeployment of resources to obvious research gaps can be addressed, given existing resource availability constraints. With producer funding, variety development can be focused on priority needs; however, in a world of minimal public funding, producer funds will need to be directed towards discovery research (an industry good).

Annex D – Summary of How Producers are Involved in Variety Development

The following three Annexes provide an overview of variety development and associated producer involvement in a few jurisdictions. A high level summary of how producers are involved in these existing models is provided in Table D.1 and D.2. This summary provides some learnings and can assist identification of attributes that could be beneficial to wheat and barley producers in western Canada.

In Table D.1, the first column suggests the main insight for the working group from each example that was summarized. For example, in the case of Australia it is the importance of partnerships, in the case of France having a uniform EPR is an attribute with considering, and in Uruguay a royalty is collected on seed used, versus on grain sold.

The second column provides a brief statement on how producers are involved. In the U.K., for example, producers have limited involvement in variety development. In other jurisdictions, producers are well represented on decision making bodies influencing variety development.

The third column in Table D.1 provides a summary of the use of levies and royalties in each of these variety development systems. A number use both a producer levy system and a method for breeding companies, including those owned in whole or part by producers, to capture the value of varieties developed. For example, in Uruguay, there is a 0.4% levy used to fund research and an extended royalty system is used on all seed planted in a year. A similar approach is used in Australia with a producer levy to fund variety development and product developers can capture royalties through an EPR on released varieties.

This summary of how producers are involved (in the middle column of Table D.1) is further examined in Table D.2, by classifying the system reviewed by the following list[31]:

- Producer direct funding of wheat and barley variety development (WBVD);
- Producer business structure;
- Producer use of partnerships;
- Producers involved in governance and direction of variety development direction;
- Stages of variety development as a focus of producers;
- In-house or contract research and variety development;
- Value capture;
- Producers capture royalties;
- Level of producer involvement;
- Applicability to wheat and barley in western Canada;

Producers are involved in many jurisdictions through a check-off system, where with a portion of these funds used for variety development producers fund variety development (see first column of Table D.1). In a number of cases, producer dollars fund variety development at public institutions. In most examples, where producers fund variety development, they have partnerships with public institutions (P3) and sometimes they have P4 arrangements, as can be noted in the third column in Table D.2. As well, when producers fund variety development, they have some involvement in governance and establishing priorities for wheat and barley variety development (WBVD).

[31] These are not assessment criteria used later to assess potential modules for consideration in western Canada. In a following section, assessment criteria are used to evaluate some potentials options for producer involvement in wheat and barley variety development. The criteria groupings are: (1) allows for a robust variety development sector; (2) allows for producer leadership and influence; (3) allows for an easy transition to the proposed model; (4) provides necessary economic incentives to breeders; and (5) leads to the desired outcomes.

Table D.1 Some Summary Findings on Variety Development and Producer Involvement

Item	Main Insight for Working Group	How Producers Are Involved	Levies and Royalties
Australia	Partnerships developed between GRDC and government and between GRDC, universities, and private seed companies	Producer help fund GRDC and are on GRDC Board. Producers are also on regional panels allowing for producer influence on direction of variety development	Use variety specific EPR on new releases and a check-off levy of 1% of sales to fund GDRC with further 0.5% government matching
Uruguay	Use an extended royalty system based on seed planted, a high level of value capture, but on-farm data capture likely intrusive	INIA was designed to be responsive to producers and others, with a four person board of directors with two members from producer organizations. Five regional experiment stations has an advisory council (including producers) providing input on priorities	Use extended royalty on certified and FSS seed, and a 0.4% check-off
France	Uniform EPR (CVO) on all varieties provides an immediate royalty scheme	Producer Involvement is through Limagrain, a larger producer co-operative seed company	A uniform EPR (~$1.10/tonne) is collected on all wheat sold. 85% is returned to variety owners.
United Kingdom	Importance of a body that provides basic discovery research	Producers had a limited role since privatization in 1985	FSS royalty is collected by seed cleaning firms at a rate of 52.5% of certified seed rate
United Soybean Board	Producers fund variety development in collaboration with private seed companies	Direct and contract research supporting variety development	Royalties on seed sales and a 0.5% check-off levy on soybean marketings funds USB
Vineland Research & Innovation Centre (Ontario)	Government supported a new business model for research and development in the horticultural sector	Producers are on the independent board and all producer groups are represented on the advisory committee. Producer groups funds specific projects	No levies, with royalties captured on commercialized innovations
Kansas, North Dakota & Nebraska (Wheat)	In Kansas, public varieties accounted for just over one-third of wheat acres. Universities dominate wheat breeding in North Dakota and Nebraska. Certified seed in Nebraska is growing due to expansion of Clearfield winter wheat varieties (requires use of certified seed and prohibits FSS).	In Kansas, North Dakota and Nebraska, the wheat commissions fund projects carried out at their state university. The KWC through the KWA licenses traits that producers find valuable and has KSU develop varieties with the trait. The KWC is also part of a P4 that does contract research. The Nebraska Wheat Board requires that the UNL provide a report on its wheat breeding activities each year.	In Kansas a $0.75/tonne assessment on wheat, with ~ 20% allocated to research. KWC receives royalties on varieties released by KSU. North Dakota has a $0.55/t check-off on wheat, a portion funds variety development at NDSU. Nebraska has a 0.4% of value check-off, with 1/3 direct to variety development. North Dakota and Nebraska growers do not capture any value.
Canadian Canola	Private sector investments occur when royalties can be captured on a large acreage crop	Direct producer involvement in breeding is limited. Producer check-off dollars are used to fund agronomic research, some pre-breeding, and policy.	Seed companies receive revenues from hybrid seed sales
Saskatchewan Pulses	SPG was established as the one industry voice to fund and direct research.	SPG undertakes a number of activities and is directly involved in funding variety development and has considerable influence on the focus and direction of variety development.	Use a non-refundable levy of 1% on sales, and SPG captures royalties through licenses
Montana, North Dakota, Idaho & Oregon (Barley)	There is a very significant amount of malting barley variety development by the private sector (brewers, malster and a seed company).	Check-off funds are used to fund projects at state universities and USDA-ARS.	In North Dakota check-off is $0.92/tonne with about 13% going to research. The Idaho check-off is $0.66/tonne with 27% going to research. Oregon has a $1.10/tonne assessment. Montana has a $0.66/tonne check-off with a small amount used for variety development. Producer organizations do not receive any royalties.

In terms of what stage of variety development producers are involved; this can range from mostly pre-breeding to mostly finishing (see the fifth column in Table D.2). Where producers are involved in these stages of variety development can depend on the where private breeding companies are prevalent, and the nature of producer partnerships.

This involvement in pre-breeding, breeding, or finishing is mostly through contract research versus in-house capability. An exception is Australia where the system was designed to foster producer investment in both discovery research and breeding.

Table D.2 How Producers Are Currently Involved in Variety Development

Approach Example	Producer direct funding of WBVD	Producer business structure	Producer use of partnerships	Producers involved in governance & WBVD direction	Stages of WBVD (focus of producers)	In-house or contract	Value capture	Producers capture royalties	Level of producer involvement	Applicability to Wheat and Barley
Pulses (SPG)	Checkoff	Producer organization	Yes - CDC	Yes	Breeding Finishing	Contract	Licenses	Yes	High	Possible
Canola (private sector)	No	Producer organization	No	No	None	NA	Hybrids	No	Minimal	No
Soybeans (USB)	Checkoff	Producer organization	Yes	Yes	Pre-breeding	Contract	Licenses	?	Medium	Parts
VRIC (Ontario)	project specific funding	In-house and contract	Yes	Yes	All stages	Both	Licenses	Possible	High	Possible
Australia GRDC	Checkoff	Non-profit	Yes	Yes	Mostly pre-breeding	Contract	EPR	Yes	High	Possible
Australia P4 Breeding Companies	levy assisted start-up	For profit	Yes	Yes, in most	Breeding and finishing	In-house	EPR	Re-invested	Medium	Possible
Uruguay (INIA)	Checkoff	Non-profit	No	Yes	All stages	In-house	ERS	Re-invested		Parts
France (Limagrain)	No	Cooperative	Yes	Yes	Breeding Finishing	In-house	EPR	Yes within Cooperative	Medium	Parts
UK (Privatization)	No??	NA	No	No	None	NA	EPR	No	Minimal	No
Kansas (Wheat)	Assessment	Producer organization	Yes (Extensive)	Yes	All stages	Contract	Licenses	Yes	High	Possible
Nebraska (Wheat)	Checkoff	Producer organization	Yes	Yes	All stages	Contract	Licenses	No	Medium	Possible
North Dakota (Wheat)	Checkoff	Producer organization	Yes	Yes	All stages	Contract	Licenses	No	Medium	Possible
Montana (Barley)	Checkoff	Producer organization	Yes	Yes	All stages	Contract	Licenses	No	Medium	Possible
North Dakota (Barley)	Checkoff	Producer organization	Yes	Yes	All stages	Contract	Licenses	No	Medium	Possible
Oregon (Barley)	Assessment	Producer organization	Yes	Yes	All stages	Contract	Licenses	No	Medium	Possible
Idaho (Barley)	Checkoff	Producer organization	Yes	Yes	All stages	Contract	Licenses	No	Medium	Possible

Each example reviewed had a method to capture value, and in some cases producers captured royalties on their investment in variety development through licenses and EPR systems.

A few of the existing approaches use an EPR system to fund variety development. On a per tonne of wheat measurement, the Australian wheat variety development system is estimated to outranks other countries[32]. Table D.3 estimates the annual expenditure on variety development at $4.50 per tonne of wheat output in Australia, which significantly outperforms the other countries, with Canada at approximately $1.67/tonne.

On a per acre basis, the UK appears to have the largest expenditure per acre at just over $7.00, which due to high yields results in a lower ranking using tonnage. In the UK, public funding of basic discovery research that now supports the wheat industry results in an estimated higher spend from the public than estimated for private sector seed companies.

[32] Expenditures by GRDC have been allocated two-thirds to producers and one-third to the public.

Table D.3 Estimated Expenditures on Variety Development, Selected Countries

Item	Units	Canadian Wheat	Australian Wheat	French Wheat	UK Wheat
Expenditures on Variety Development	*$ million*	**$46.1**	**$104.7**	**$40.0**	**$34.3**
Private	*$ million*	$6.2	$47.6	$40.0	$11.3
Producer	*$ million*	$6.2	$38.3		
Public (Government and Universities)	*$ million*	$33.7	$18.8		$23.0
Farm cash receipts	*$ million*	$5,628			
Expenditures per 1$ of cash receipts	*%*	0.8%			
Acreage	*million acres*	22.6	34.1	13.1	4.7
Expenditures/acre	*$/acre*	$2.04	$3.07	$3.05	$7.31
Production	*million tonnes*	27.5	23.0	38.0	16.6
Expenditure/tonne of output	*$/tonne*	$1.67	$4.55	$1.05	$2.07
Seed purchases (sales by seed companies)	*$ million*	$181			
Expenditures per $1 of Seed Sales (purchases)	*%*	25.5%			
Seed purchases as a % of cash receipts	*%*	3.2%			

Source: Consultant estimates compiled from various sources.

The last column in Table D.2 provides a high level view of whether the existing system we profiled can be implemented in western Canada for wheat and barley, when viewed through the lens of producer involvement. The consultants view is that:

- Parts of the model used by SPG are applicable, such as the partnership with CDC;
- The canola model is likely not applicable simply due to minimal producer involvement;
- The contracting out of research by the USB is already a feature of the current system, and can continue for wheat and barley;
- Taking over ownership of former government research facilities is an option that can be considered by wheat and barley producers, and is already in practice through FCDC in the case of barley, and VRIC in Ontario;
- The GRDC producer-public partnership approach in Australia is a model of producer involvement that can be considered by producers in western Canada;
- Also, the resulting P4 models in Australia that were used to establish plant breeding companies are applicable for consideration for producer involvement in breeding, finishing and commercialization;
- Parts of the Uruguayan model can also be considered (collection of royalties on farm saved seed; however, the method of collection is likely impractical and intrusive);
- The uniform EPR is a feature of the French model can be considered, assuming accompanying legislative change;
- The UK model provides the simple lesson that pre-breeding activities cannot be privatized, suggesting that producers need to ensure that such activities that generate industry goods remains well funded;
- In Kansas, wheat producers have a high level of involvement through partnerships, and value is captured. In the other US states examined, medium producer involvement was exhibited, with limited partnership, and no value capture;
- Wheat varieties with use agreements, such as Clearfield in Nebraska, can result in very high use of certified seed, which provide benefits to farmers and, and certified seed sales of over 70% in Nebraska winter wheat provide economic incentives for breeding companies, which can also benefit producers through partnerships with plant breeding companies.

Annex E - Producer Involvement in Variety Development in Some Other Crops

Producers are involved in variety development in other crops, such as pulses and canola in western Canada, soybeans in the United States, and horticultural crops in Ontario. A brief overview is provided in this section to provide additional context for how producers could potentially be involved in variety development of wheat and barley.

E.1 Pulse Crops in Saskatchewan

Within western Canada the success of pulse breeding can be seen as an example of outstanding success. Pulse crops have risen from relative obscurity in western Canada 40 years ago to become an important part of crop rotations in nearly all regions of western Canada.

Variety Development Focus in Pulse Crops

The growth of the Saskatchewan pulse industry began with lentils and spread to other pulse crops as research resources and breeding programs expanded. Lentils were initially grown by a few farmers as a cash crop in the late 1960's, during a period of difficult cereal grain markets. The first major success in lentil breeding was achieved by Dr. Slinkard at the University of Saskatchewan, who released Laird and Eston lentils, in 1978 and 1981. These green lentil varieties were adapted to specific prairie growing conditions, which improved maturity, crop stands and yields.

Subsequent research and development has allowed the Canadian lentil industry to be a growth sector. Both green and red Canadian lentil varieties have seen large productivity growth. In red lentils there has been a three percent annual increase in yield potential of new varieties released over the past five years. These higher yielding varieties reduced production cost, which has been a source of competitive advantage to the Canadian lentil producers. Today, the Canadian lentil industry, almost exclusively located in Saskatchewan, is the world's largest lentil producer and dominates global lentil export markets.

Genetic advances have also been very significant in chickpeas, yellow field peas, green field peas, and most recently, faba beans. In chick peas, breeding has focused on improved disease resistance and shorter season varieties. In field peas, the development of better-standing leafless varieties, has increased yields by 60% over the last 15 years. In faba beans, the development of smaller seed varieties has made the crop much easier to plant with modern seeding equipment. Non-genetic advances, including land rolling and seed inoculants, have also contributed to the viability of pulse crops.

Funding and Value Capture Model

Much of the successful development of the Saskatchewan pulse industry can be attributed to breeding funded by the Saskatchewan Pulse Growers (SPG). The SPG was established as a Board under the *Saskatchewan Agri-Food Act and the Natural Products Marketing Act*, with a non-refundable check-off at 0.5% of gross sales. As the breeding success contributed to industry growth, levy revenue and research expanded creating a positive feedback through further research and development.

In 2003, after a favourable review of the rates of return, growers supported a move to increase the funding level equal to 1.0% of gross sales, a much higher check-off rate than other field crops in Canada. In both 2013 and 2014, the SPG had a levy income of approximately $13 million, the majority of which is invested in research and breeding activities.

The SPG employs several different variety release approaches (or models) to effectively commercialize their varieties. With their secure funding base the SPG entered an agreement with the Crop Development Centre (CDC) to fund a pulse breeding program where the SPG is granted exclusive control of all new varieties created from the CDC breeding program. The variety release models used by SPG include the following:

1. The most common model is a general variety release program, where breeder seed is widely distributed to interested seed growers for commercial multiplication and royalty free seed sale.
2. Given the royalty free nature of these varieties, and the 1% levy on farm marketing, farm-to-farm "brownbag" sales are not discouraged by the SPG.
3. After a new variety has been established in Western Canada, the SPG chooses to grant the international rights to the CDC, which in turn enters into an agreement with an international seed company. The CDC receives royalties on associated international seed sales.
4. For smaller market classes (e.g., Spanish brown lentils, extra-large red lentils) that require marketing investments to develop a market, the SPG has entered agreements where one firm is granted an exclusive license to all forthcoming varieties for that class for a specific number of years. This gives the private firm the incentive to make market development investments to develop the market without any fear of competition during this development process.
5. SPG entered into a license agreement with BASF, who owns the Clearfield herbicide tolerance trait. Prior to the release of a new variety, the process of incorporating the non-GM trait into that variety is undertaken by the CDC. The year after the non-herbicide tolerant variety has undergone general release the herbicide tolerant version of the variety is released. BASF captures the value through the growers' use of the herbicide, which benefits growers by not having a technology fee attached to the seed purchase. This long-term relationship has worked well, maintaining producer control over the SPG varieties, while creating access to privately owned technology that can benefit producers.
6. The also SPG operates what is referred to as the Pea Genetic Improvement Program (PGIP) that makes payments to pea breeding companies based on market share in Saskatchewan. They currently make available about $800,000 through this program, with payments to the companies involved in this program made based on market share (a weighted average of commercial and registered/certified seed acreage). The goal is to encourage companies to bring pea varieties to market in Saskatchewan and provide a revenue capture opportunity.

With these six approaches to SPG variety release, the CDC's breeding programs have become a source of genetic advancement. These varieties and other innovations are part of the competitive advantage that has enabled Saskatchewan producers to expand production and become the dominant exporter of lentils in the world.

The research and breeding efforts of the levy funded SPG have also received substantial direct financial support from the government of Saskatchewan through the Agriculture Development Fund (ADF), and a good deal of in-kind support from AAFC scientists who have contributed to the development of disease resistance, pea genetics, agronomics and processing, and through Pulse Canada, a largely federally funded organization that has played an important role in market development.

It should be noted that SPG needed to invest in variety development given the initial acreage base of pulse crops and the low level of private sector interest in investing in variety development for crops with a small acreage base. This is a critical feature of the development of the pulse industry and the research and variety development model used

Research Coordination

While the financial investments of the SPG have directly played a very important role in the development of the pulse industry in Western Canada, this measure understates the importance of SPG. The SPG organization has played a critical role in creating a systematic strategic approach to industry development that was able to identify research extension and marketing needs, garner resources, and coordinate the research activity. An official in the Government of Saskatchewan once noted that funding requests from the SPG were difficult to ignore because SPG knew exactly what they wanted and could provide a rationale for their request. Strong active producer representation on the SPG board of directors has allowed this organization to accurately identify research needs and allocate scarce research dollars to where they are needed most. The result has been the rapid development of the pulse industry in Canada.

This national coordination of pulse research differs somewhat by pulse crop. SPG is dominant nationally in lentils, chick peas, and to a lesser extent in field peas. Until recently soybeans had been predominately grown in Ontario. With the development of short season soybean varieties, Manitoba and potentially Saskatchewan, may become large soybean producers. This, in turn, might create the need for a national approach to soybean development.

Pulse Comparisons to Wheat and Barley

Unlike the wheat and barley industry, which has suffered a significant decline in the share of Canadian production, the pulse industry has enjoyed a get deal of success in both absolute and relative terms. Pulse crops have enjoyed high rates of yield growth and have increased in area to become a $1.5 billion industry at the expense of area sown to wheat and barley.

The success in relative terms for pulse crop development compared to cereals can be attributed to a number of factors, Including:

- Pulse crops have a relatively simple genetic structure and are relatively new to systematic breeding. In other words, there was more low hanging genetic fruit to be exploited.
- The SPG was set up as a board with a non-refundable levy that has enabled the SPG to employ a much higher levy rate without the danger of free riding. SPG invests grower check-off (levy) dollars in areas such as R&D and variety commercialization, as well as in areas such as market promotion and communications to benefit the Saskatchewan pulse industry. The success in research enhanced the support for the organization.
- The SPG provides the industry with one voice when it allocates scarce research funds. This ability to speak as one voice for the industry was bolstered by the fact that 80% of pulse crops grown in Canada are grown in one province, giving the SPG a dominant voice in research funding.
- The choice to support a single breeding institution – the CDC - has led to success and perhaps was a key element in the success.

Similar to wheat and barley, there has been a lack of investor-owned, for-profit private investment in the Western Canadian pulse industry. Despite some effort to attract private research, the very effective producer funded research program in pulses, giving producers royalty free access to superior varieties, has likely crowded out other private investment. The potential small acreage for new varieties is not a large incentive for private investors. Going forward, the introduction of soybeans in Western Canada may create a new dynamic for private research as the international landscape for soybeans is dominated by private firms that are able to protect their soybean varieties through patents and license agreements.

E.2 Canola

Canola, known as Canada's Cinderella crop, has enjoyed remarkable success in research and genetic advancement. The yield index of Canola, at 170% of the 1960 index, has shown over twice the gains realized in wheat and barley. As a result of this increase in yield potential, canola's production area has spread from its original home in the black soil zone to cover most of the prairie region, allowing canola to rival wheat as the most important crop in Western Canada.

Variety Development Focus

Much of canola's success can be attributed to successful breeding. The crop, formerly known as rapeseed, was initially grown in small acreages for use as a marine lubricant. In the late 1950's public researchers and processing companies developed processing technology to refine rapeseed oil for human consumption. When it was subsequently discovered that high levels of erucic acid in the oil created human health hazards and the glucosinolates in the meal created challenges in feeding, breeders set out to address these problems. In 1972 Keith Downey and Baldur Stefansson succeeded in breeding rapeseed varieties low in glucosinolates and erucic acid. This transformation of rapeseed which gave the crop its Cinderella nickname, became trademarked as Canola and received 'Generally Regarded as Safe Status' for the US Food and Drug Administration in 1975.

Herbicide tolerance was introduced in canola in 1997. New varieties trademarked under RoundUp Ready, Clearfield and Liberty Link provided three alternative herbicide tolerant systems that could be protected by patents. These systems were shortly followed by the introduction of hybrid canola varieties which exhibited heterosis with significantly higher yields. The transformation to hybrids was quite rapid as hybrid seed varieties led by Invigor 5440 which showed a 35% yield increase over non-hybrid check varieties. Post hybridization genetic yield gains, beyond those achieved with Invigor 5440 introduced in 2005, have proved difficult to achieve. During the last decade RoundUp Ready and Clearfield varieties have closed the gap with Invigor 5440. In 2014 Bayer Crop Science introduced Invigor 251 and 262 which report higher yields than 5440, perhaps signaling the end to the dominance of this variety and the beginning of a new wave of genetic advancement.

Funding and Value Capture Model

The funding model for Canola differs significantly from wheat and barley, and pulse crops. Prior to 1985 rapeseed and canola breeding in Canada relied on public resources for breeding along with a few varieties imported from Sweden. Post 1985, there was a significant influx of private investment in canola, which accompanied the biotech boom and the entry of large pesticide companies into the international crop breeding industry. AAFC, the University of Manitoba, and the University of Alberta Canola varieties dominated the Canadian Canola industry until 1990. During the 1990s AAFC withdrew from variety commercialization and supported the entry of private firms by sharing germplasm and doing supporting upstream research[33]. By 2005 the canola industry had shifted to privately owned hybrid seed varieties.

An accurate time series of private research expenditures is difficult to obtain. It is clear the private industry has invested over $50 million per year in Canola breeding for a number of years. This investment increased from ~$30 million in 2001 to $42 million in 2007 and approached $65 million in 2012. This breeding activity continues to be supported by public pre-breeding research, including genomic research.

[33] Carew examined changes in professional and technical staffing levels in publicly funded canola research in Canada from 1986 to 1998. He found that in 1986 canola breeding/reproduction had 20.5 professional person-years and 24.4 technical person-years. In 1998, professional person-years had fallen to 8.0 while technical person-years had fallen to 7.8. (Carew R, "*Intellectual Property Rights: Implications for the Canola Sector and Publicly Funded Research*", Canadian Journal of Agricultural Economics, Volume 48, 2000, 175-194.

Hybrid seed technology has enabled private firms to capture the value embodied in new varieties. Hybrid seed prices are substantial, providing the seed industry with typical seed revenue over $60 per acre. With 20 million seeded acres the gross revenue for the seed industry exceeds $1 billion annually. Given seeding rates and typical hybrid seed production costs, most of the seed revenue accrues as rent to variety owners. With typical gross revenue of about $400 per acre Canola producers pay about 15% of gross income to purchase seed. In turn the seed industry invests about 10% of their gross revenue in breeding related activities.

While private investment dominates canola investment, there continues to be significant upstream (pre-breeding) public support for Canola research. Growing Forward 2 has supported Canola Research Clusters led by the Canola Council and by Sask Canola. Grower organizations fund agronomic research, market development and policy research through provincially based check-offs of $0.75 per tonne. The Canola Council of Canada, who provides a voice for the industry, is funded through export and processing levies and direct membership fees.

Coordination

The Canola Council of Canada, which includes representation of growers, processors, breeders and exporters, represents the industry on a number of fronts. As representative of all aspects of the industry, the Council provides a powerful industry voice.

Provincial grower organizations and the Canadian Canola Growers of Canada retain their own policy capacity and can speak independently from the Canola Council. Historically the grower groups have been proactive in extension and agronomic research to increase industry productivity. These groups have worked together to address general concerns to the industry, for instance Clubroot disease management.

There are many canola breeding programs in western Canada, including those led by Bayer Crop Science, Monsanto, Pioneer Hybrid, Dow Agri Sciences, Cargill Ltd, DL seeds, Bret Young and others. The large number of firms suggests there could be substantial duplication of breeding effort. Since 2005 some companies have entered cross-licensing agreements, but it is unclear to what extent germplasm and other forms of intellectual property are shared across these breeding programs. Notably, disease resistance traits do not tend to be common across the registered varieties.

The amount of coordination between public research, producer controlled research, and private research is unclear. AAFC continues to undertake upstream germplasm development. Producer groups tend to focus on agronomic practice and variety testing.

Canola Comparisons to Wheat and Barley

Canola is an outstanding model of success that differs from wheat and barley in a number of fundamental ways. First of all, until recently, the genetic gain measured as the area weighted yield index of new varieties, has been almost double the gain in wheat since 1960. The faster genetic gain occurred in both the non-hybrid public breeding period and during the period of hybridization and privatization of Canola breeding. At the farm level the increased yield potential has allowed Canola to expand to 20 million acres, a land base that is beyond original suitable production areas in the black soil zone with production now occurring in all crop districts in western Canada[34].

Many reasons have been given for the faster genetic gain in canola versus cereal grains. Canola is a relatively new crop to commercial breeding, and therefore “low hanging fruit” was available to a

[34] Terrence S. Veeman and Richard Gray, “*The Shifting Patterns of Agricultural Production and Productivity in Canada*” in The Shifting Patterns of Agricultural Production and Productivity Worldwide. The Midwest Agribusiness Trade Research and Information Center, Iowa State University, Ames, Iowa (2000).

systematic research approach. Canola hybrids have a great deal of heterosis. Finally, canola has a much higher level of breeding investment. It is worth noting that while early hybrids provided a great deal of yield growth, post 2005 the rate of genetic improvement yield has slowed considerably despite significant private investment.

Wheat and barley breeding is done at public institutions funded predominately from taxpayer and levy paying producers. Cereal varieties coming from these programs tend to be widely distributed with modest certified seed royalties, making the varieties very affordable to producers. Estimates are that wheat royalties generate about $5 million per year in royalty revenue[35]. In contrast, Canola is dominated by privately owned hybrid seed varieties, which are sold at high prices to producers each year, generating over a $1 billion in seed sale revenue. In turn, private companies currently invest a total of about $65 million in breeding related activities. With Canola farm cash receipts of over $7 billion, this indicates that the breeding research intensity is ~ 1.0% of gross crop income, a level that is above the levels found in other crops.

While producers have enjoyed the benefits of varieties that yield far more than the open pollinated non-GM varieties, they pay large amounts to access the privately owned hybrid canola germplasm. For wheat and barley, producers are able to access new varieties at modest cost. When given a choice between paying a high seed cost to grow canola and growing alternative crops of low cost varieties, such as wheat, producers continue to choose Canola.

At the same time, with minimal producer involvement in canola variety development, there can be shortcomings. Private seed companies, which are also life science companies, may decide that a focus on certain herbicide resistant traits is more profitable than focusing on other types of variety improvement (e.g., hairy canola). This can be a shortcoming a variety development system with minimal producer involvement.

The ability to attract large amounts of private investment into Canola was created first by herbicide tolerant traits, which farmers were willing to pay for, and later by the shift to hybrids, that created a very large one-time increase in yields. If wheat remains non-GM and the heterosis in hybrid wheat does not result in significant yield increases, wheat cannot follow canola's path to privatization. Even if private companies were to introduce herbicide tolerant GM wheat, there may be far more limited willingness to pay for this technology given the effectiveness of the herbicides already in place for wheat, which was not the case for canola. The same argument can be made for new wheat varieties with license agreements, such as with a Clearfield wheat or barley variety.

Although UPOV 91 does create a platform for stronger intellectual property rights, without a significant jump in the value of new cereal varieties, the new varieties will face steep competition from existing, largely royalty-free, wheat and barley varieties. This is a fundamental difference with canola.

E.3 United Soybean Board in the United States Funds Variety Development

The United Soybean Board (USB) in the US is another example of producer involvement in variety development. The USB is funded by soybean farmers through a mandatory check-off of 0.5% of the market price per bushel sold each season. For example, when soybeans are $9.00/bushel, the check of is 4.5 cents/bushel, or $1.65/tonne. Given the acreage base of soybeans in the US, the check-off generates just over $100 million in annual funding. The USB carries out a coordinated program of promotion, research, consumer information, and industry information mostly through contracts.

[35] Information is not available on royalties generated on barley seed sales.

In addition to private sector investment in variety development, the USB in 2013/14 invested $22.1 million in soybean variety development. This was 33% of all of their research spending in that year[36]. This spending is directed through contracting to researchers and seed companies. In 2013/14, funding by areas was as follows:

- Soybean Germplasm and Variety Development $11.3 million (over 44 projects);
- Variety Testing and Germplasm Screening $1.6 million (over 32 projects);
- Gene Discovery and Bioengineering Studies $9.2 million (over 71 projects).

The USB has invested heavily into development and market expansion of Hi-Oleic soybean oil and has partnered with a number of seed companies to assist development of Hi-Oleic soybean varieties. These varieties are designed to regain market share in the edible oil world as soybean oil has lost share to canola oil and the trend away from hydrogenated oils.

This mandatory check-off authority was provided in 1991 and USDA's Agricultural Marketing Service has oversight responsibilities for USB and the soybean check-off. The USB has 70 farmer members representing 29 States and 2 combined regional units. The Secretary of Agriculture appoints approximately one-third of all Board members each year for 3-year terms. The Board develops budgets and uses contracts to deliver on its programming.

The USB is an example of producer involvement in variety development, even when the private sector is actively involved in variety development. The USB allows for producer involvement through the board's allocation of fund to priority areas, including variety development.

E.4 Vineland Research and Innovation Centre (in Ontario)

Vineland Research and Innovation Centre (VRIC) in Ontario is a P4 partnership which is focused on innovation in the horticultural sector, with a downstream focus on the innovation continuum and speeding up the time to commercialization of new technologies[37]. The VRIC was originally the Vineland Research Station (started in 1906) and then renamed as the Horticultural Research Institute of Ontario (HRIO) in 1945. The research facility was owned by the Government of Ontario until 1996 when its management was transferred to the University of Guelph.

For a number of reasons, by 2005 a new course and focus was required for HRIO. These reasons included budget cut-backs, the physical infrastructure needing upgrading, a need for a new strategic direction for the facility, a fragmented innovation system that was somewhat isolated from sector needs versus being market focused, and to some HRIO was no longer relevant to the changing needs of government, producers and consumers. Survival of the soft fruit industry in Ontario required an innovation system that could produce tangible results and enable the sector to be competitive with competing jurisdictions. The VIRC emerged as a P4 in 2008 as part of an Ontario government initiative to re-vitalize the horticultural sector.

Partnership is an important part of the VRIC business model and can be viewed as a major key to success for the organization. VRIC has partnerships with government, universities, the private sector including downstream organizations, and producer groups.

[36] Research expenditures were $66 million, with other spending on areas such as promotion and market development.

[37] Information sources for this section on VRIC include (1) personal communications with Tania Humphrey, Vineland's Director of Research Planning and Research Management, (2) a review of selected VRIC reports, and (3) a VRIC case study contained in the report by Phillips P, W Boland, and C Ryan, "Public-Private-Producer Partnerships (P4s) in Canada", Report for AAFC, 2013.

There are a few ways producers are involved in VRIC, such as:

- There are producers on the Board, with this producer representation independent of any producer organization. These board members are not advocates for any organization;
- Producer influence is through an advisory body of approximately 15 members, with each commodity group represented by an executive of their organization. The complete value chain is represented on this advisory body, which provides input to VRIC's senior management;
- Producers also fund specific projects of interest to their organization. In this manner they can directly affect the type of research undertaken by VRIC.

When a producer organization contributes to a technology that is licensed to a third party, the producer organization shares in the royalty stream. The ideal situation is for the producer organization to reinvest the royalty payments back into further innovations at VRIC[38].

There are no annual producer organization contributions to on-going VRIC operations through a mechanism such as a check-off levy. This is due in part due to the low marketplace returns to producers at the time VRIC was formed. The annual budget of VRIC is approximately $10 million, with 59% of this coming from government as core funding (via contracts), around 15% of funding comes from the private sector (which includes royalties, contract research, and producer contributions to specific projects), 10% is based on competitive grants from government bodies, and the remaining 18% is classified as other.

There are 70 employees at VRIC, with the research conducted at VRIC, as well as collaborations with industry and/or academic researchers. A large focus is on innovation and commercialization. As a result, projects with industry are downstream in nature. Commercialization approaches include licensing IP and technologies to industry and capturing a royalty stream for VRIC.

The VRIC also has upstream research, with such research collaborative in nature with the university sector, which allows the university to focus on discovery research and VRIC on the downstream component. Seed companies in the horticultural sector are not interested in upstream discovery type research – an industry good. Rather seed companies are interested in downstream research with applications in the marketplace and the licensing of new technologies.

One key to success to VRIC is the governance model. The organization and the Board are at arm's length to government. The independence of the Board gives necessary flexibility; however, the organization is still accountable to government through funding contracts. As noted above, producer influence is not at the Board level, but rather through the advisory body and funding of projects.

Another key to success is VRIC's partnership focus. This allows for its focus on projects that are of value to the horticultural industry and enables the necessary collaboration on projects. Innovation occurs in concert with others.

Partnerships with producer groups provide for more engagement in the innovation process, and provides a flow of royalty funds when the parties jointly own some intellectual property.

[38] This occurs in the asparagus industry where asparagus growers have reinvested royalties into further research undertaken at the University of Guelph.

Annex F - Producer Involvement in Variety Development with Royalties

In selected other jurisdictions where royalties are collected to support plant breeding, producers are involved in wheat and barley variety development. This occurs in Australia, Uruguay, France and the United Kingdom, and is overviewed in this section, as well as in some other counties based on UPOV 91. Royalties are collected with an EPR system, or at time of seed use as in Uruguay. This overview of variety development in other parts of the world and how producers are involved can provide insight into what works and what doesn't work with respect to producer involvement in wheat and barley variety development.

F.1 Wheat in Australia

Operating through the Grains Research and Development Corporation (GRDC), Australian grain producers have had a large influence on the development of the agricultural research and development system[39]. The GRDC is a producer-controlled organization that was established in 1989 after the passage of legislation by the Australian government. The GRDC is funded by a 1% levy on the sale of 25 field crops which is matched 0.5% by the Government of Australia. In 2014 the GRDC received $200 Million in revenue: $120 million of levy; $68 million in national government contribution; and $20 million and royalty and interest income.

The Board of Directors of the GRDC are appointed by the Australian government. However, six of the eight Directors are nominated by a farm organization – Grain Producers Australia (GPA).[40] The GRDC reports annually to government and to the GPA. In addition to the Board of Directors, there also are three regional panels with significant producer representation. In 2013, the GRDC also created numerous Cropping Solutions Networks, which are local committees that work with each of the regional panels to define producer research needs and delivery mechanisms that will maximize producer update of new knowledge. Some industry leaders feel this latter move was necessitated by the growing perception of some producers that GRDC had lost its ability to respond to producer research needs.

The use of compulsory producer levies with co-funding by government for research and promotion has been in existence in Australia for over 50 years. As well, while the GRDC, as with other research and development corporations (RDCs), were established in 1989 by legislation, they are the outgrowth of former processes to allocate these producer check-off (and government) funds. Initially statutory advisory committees were used (with representation from producer groups, Commonwealth Scientific and Industrial Research Organization (CSIRO), and the government) to allocate funds to priority areas. These committees were replaced by councils for administering the funds; however, there was a general concern with the outcomes of these expenditures. The RDCs were established based on a corporation model, premised on the need to give the RDCs operating and financial flexibility and increase the efficiency with which R&D funds were spent. Each RDC was to focus on the needs of its industry, and invest in R&D to develop and contribute to the profitability and competitiveness of the industry. The model was designed to better reveal industries research priorities. Unlike the previous committees and councils, which relied on researchers to set the agenda, the RDC model has strong linkages with producers. The significant contribution that

[39] The source for this overview of the Australian system is based on (1) Alston, J. M. and Gray, R. S. (2013), *Wheat Research Funding in Australia: The Rise of Public–Private–Producer Partnerships*. EuroChoices, 12: 30–35. doi: 10.1111/1746-692X.12017; and (2) personal knowledge of one of the consultants (Gray).

[40] This governance structure has become an issue. Some producers are questioning whether the GPA is the most legitimate representative of producers. Other producers are arguing for the GRDC to become a private corporation, with a producer elected board of directors and without matching levy support from the government.

producers make to the cost of the R&D helps to ensure effective use of funds. The research brokering function of RDCs, and the large amount of funding they have at their disposal, are the reasons for the RDCs to have an appreciated 'systems integrating' role[41].

In 2013/14 the GRDC made investments of $160 million to fund research, development and extension activities. The research activities covered a broad spectrum of activities ranging from basic science and genomics research, to crop disease research, to breeding to applied agronomic research, and finally to demonstration and extension activities. Variety development competes with other research priorities of the GRDC.

Despite its large research expenditures the GRDC has less than 30% of total agricultural research in Australia, with non-grain sectors accounting for much of the other research spending. The National Government, State Governments, the private sector, other RDCs continue to invest heavily in agricultural research, the development and extension. The GRDC is actively involved in the Grains Industry National Research, Development and Extension Strategy Implementation Committee together with representatives from each of the state departments of agriculture, CSIRO, universities, industry and the Australian Government. This committee works: to harness the necessary capability (people, infrastructure and information) for present and future RD&E needs; provide shared strategic directions and priorities planning; and overcome capability gaps, create critical mass and reduce fragmentation and unnecessary duplication of effort across the nation (GRDC, 2015). As a statutory corporation the GRDC has been able to create a wide range of contractual and partnership agreements.

Producer Partnerships in Wheat Breeding in Australia

The GRDC is largely responsible for the creation of the P4 partnerships that currently dominate wheat breeding in Australia. Between 1989 in the late 1990's, the GRDC was supporting seven distinct wheat breeding programs located at State governments and universities throughout Australia. Recognizing that seven programs were too many for a small country and that eventually end point royalties could support commercial wheat breeding, the GRDC indicated they were willing to participate in up to three partnerships to undertake wheat breeding and solicited partnership proposals.

As a result of this process, three new wheat breeding firms were established with public (State government and University), producer (GRDC) and private shareholders. The GRDC and government continued to support breeding activities while these made the transition to commercial viability. The private partners provided technology in return for access to germplasm. Some firms purchased shares providing additional start-up funds.

Today AGT (Australian Grain Technologies) is the largest wheat breeding firm in Australia. AGT was established in 2002. The current shareholders are GRDC, Limagrain (via Vilmorin & Cie), the South Australian Government, and the University of Adelaide. AGT currently manages four significant regionally based wheat breeding operations at Northam in Western Australia, Narrabri in New South Wales, Wagga Wagga in New South Wales and Roseworthy in South Australia. These wheat breeding programs work both independently and jointly to meet the needs of western, northern, and southern Australian growers. With the recent release of the Mace wheat variety that dominates planted area in Australia, AGT receives over $35 million in royalty income, which to date has all been retained by AGT and reinvested in deepening the breeding programs.

[41] This history of RCDs and the GRDC is based on Bolek, Katarzyna (2015) "*Public, Producer, Private Partnerships and EPR systems in Australian Wheat Breeding"* Ph.D. Dissertation, University of Saskatchewan http://ecommons.usask.ca/handle/10388/ETD-2015-03-1991

The second largest wheat breeding program is undertaken by InterGrain Pty. Ltd which was established in 2007. InterGrain has several wheat breeders with active breeding programs in Western Australia and Victoria. The present shareholders are GRDC with 25%, the Dept. of Ag and Food, Western Australia (DAFWA) at 49% and Monsanto Ltd. with 26% of the shares. While having about $10 million in royalty income is sufficient to operate a viable wheat breeding program, the increased competition from the AGT's Mace wheat variety has limited the growth of InterGrain.

The third P4 GRDC partnership is HRZ Wheat Pty. Ltd. that focuses on developing high rainfall zone wheat. In 2013 HRZ Wheats was renamed Advantage Pty. Ltd. In early 2014, Dow Agrosciences Ltd acquired all of GRDC's shares in Advantage Wheat and publicly held shares resulting in 100% ownership by Dow Agrosciences Ltd.

Private investment by Syngenta and Bayer Crop Science, have further increased the private presence in Australian wheat breeding.

Use of End Point Royalties in Australia

The ability of the P4 breeding firms to become financially independent was heavily dependent on royalties. EPRs are now the primary source of funding for wheat breeding in activities in Australia. Crop royalties are collected at the point of sale of harvested product produced from protected varieties, rather than from the seed used as an input. EPRs differ from seed royalties in at least four ways.

- First, having the royalty payment based on harvested material, the breeder is able to collect a royalty even if a grower saves seed or does not buy new genetic material.
- Second, because EPRs are paid on harvested material, the breeder and the grower share production risk.
- Third, eliminating the seed royalty encourages growers to use optimal seeding rates.
- Finally, with EPRs, breeders no longer rely on the seed industry to collect royalties and instead must rely on crop marketers to enforce the royalties.

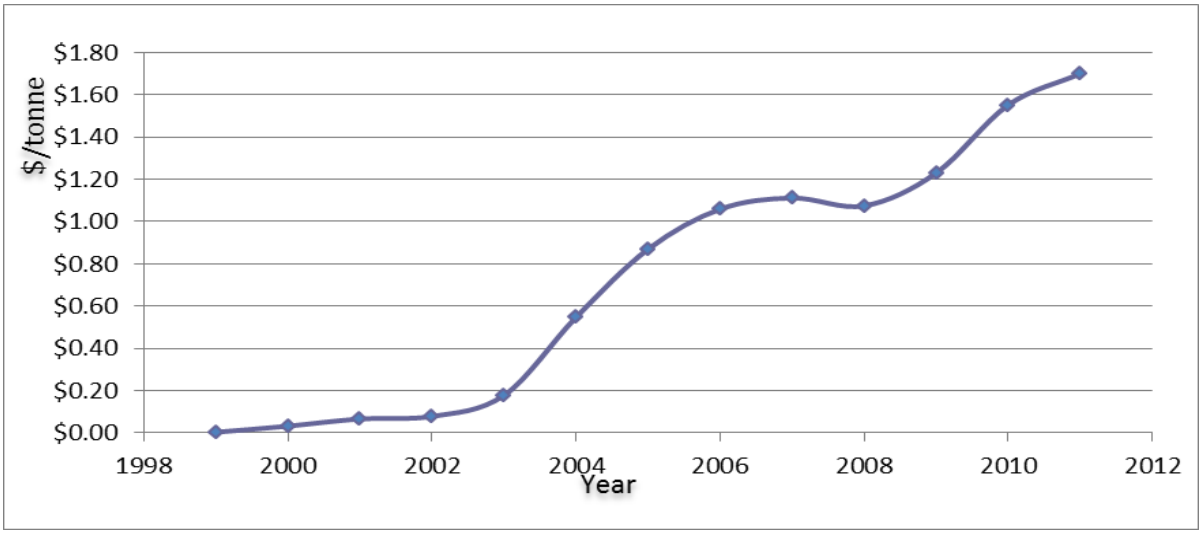
It took many years to develop a commercial revenue stream from EPRs. UPOV 91 compliant legislation was passed in 1994. In 2010, or 16 years later, the two largest breeding firms were finally at a point where EPRs would cover breeding costs. EPRs currently provide sufficient revenue to support commercial wheat-breeding activities, and EPR revenue continues to grow and is poised to grow very rapidly over the next few years as recent varieties with higher EPR rates are adopted. This will create a very research-intensive wheat-breeding sector.

The potential for EPRs to generate revenue to fund private research took many years to be realised. At least three important barriers slowed their implementation.

- First, an affordable enforceable system of levy collection had to be developed. This required the development of new licensing agreements, collection agreements, and the education of industry participants. These processes required more than a decade to develop, but the industry has now developed a standardized set of contracts, and the major breeders have agreed to use SeedVise as a single agent to negotiate and coordinate the EPR collection system.
- Second, when EPRs were first introduced, new EPR varieties had to compete with royalty-free varieties already used on farms. The availability of free varieties made it difficult to charge a significant EPR on the new varieties until they had improved to the point where producers were willing to pay a significant amount of EPR to access these varieties.
- Finally, a private industry with the incentive to charge EPRs had to evolve. As long as some public breeders in the industry were reluctant to charge EPRs, the ability of the remaining firms to charge significant EPRs was limited.

The future of EPR rates is a matter of some debate in Australia. New wheat varieties with improved yield potential and other traits are priced with higher EPRs. While varieties released in 2000 have $1.00 /t EPRs, recent varieties have $3.50/t EPR rates. The weighted average EPR rate is shown in Figure F.1, with the weighted average $1.70/t in 2011. If the P4 partnerships are purely profit oriented they have an incentive to continue increase EPRs over time. On the other hand if there is political push back from producers, State governments, and the GRDC who own the majority of shares in these partnerships, the choice may be made to limit EPR rate increases.

Figure F.1 Weighted Average EPR Rate Attached to Wheat Varieties Adopted in State of Western Australia



Source: (Bolek 2015).

Summary of Features of the Australian Wheat Breeding

- Producer control is exercised through the GRDC – a national, levy-based, government-matched, all grain, research funding organisation;
- The GRDC did support public breeding, but now is a shareholder in two P4 partnerships;
- EPRs currently provide $2.00 to $3.00 per tonne of royalty income that is being reinvested in breeding activities;
- For wheat, currently approximately $50 million in EPRs are collected in a year;
- EPRs required developing an efficient collection system and producer education;
- Strong private investment with Bayer, Dow, Limagrain, Monsanto, and Syngenta and other private firms;
- It is too early to assess breeding results but the Mace wheat variety released 3 years ago by AGT is high yielding and has quickly dominated the market;
- Pre-breeding activities continue to be supported by the GRDC and governments;
- Seed growers are used for seed multiplication and distribution. Farm to farm seed sales are encouraged fostering faster adoption and ensuring seed supply during drought.

Strengths

- EPRs now create a demand pull for new varieties and has attracted additional resources for wheat breeding[42];

[42] It can be noted that Australia does not have a merit based variety registration process. Any breeder that has "Distinct Uniform and Stable" variety can register the variety for sale in Australia. Once a wheat variety has been registered it can only be sold into a general purpose wheat class until Wheat Quality Australia, an independent, not-for-profit Company tests and classifies the new wheat varieties according to market needs.

- Producers acting through the GRDC have partnered with private firms and governments to create a well-funded well-coordinated national grain innovation system.

Weaknesses

- If current trends continue high ERP rates could substantially increase costs to producers;
- The entry of several new wheat breeding firms may be fragmenting knowledge and breeding efforts;
- The previously common practice of germplasm sharing among breeders became more restricted with the GRDC's establishment of wheat breeding firms[43].

Implementing the Australian System in Canada

The GRDC is a national body supported by a levy on all grains. A similar national approach would require federal legislation or a great deal more coordination among provincial check-off organizations. P4 partnerships would require cooperation between producer, check-off organisations, seed companies, universities and government organisations. Once producer-public partnerships are established private firms may be willing to contribute technology and be a minority shareholding partner to gain access to Canadian germplasm.

The need for partnerships in Australia arose because the breeding firms needed capital until a return could be realized, and the partnerships provided necessary investment dollars since a rather long time period occurred after start-up before the partnership could be self-funded with EPRs. Without a share of ownership by producers or the requirement for on-going support; the producers and even the public investors would have no future influence on these firms. While contract based EPRs are possible in UPOV 91, transactions costs may prevent their use without the development of national system of EPR collection.

F.2 Barley in Australia

Until the end of the 1960's, prior, a variety developed by a producer in 1903, was the dominant barley in Australia. During the 1920's to 1950 there was some small scale part-time barley breeding efforts in Victoria, New South Wales, and South Australia. In 1956, malsters, brewers, growers and the commonwealth government (which contributed matching funds) established a barley improvement scheme. This resulted in full-time breeding programs in South Australia and Victoria. Varieties from this program eventually replaced Prior.[44]

From the late 1970's to 1990, research councils funded research in different crops, including barley. In 1990, the GRDC was created through the amalgamation of four federal research councils and ten state wheat and barley committees. The GRDC's overall responsibility was "*to drive research and development across the entire Australian grains industry*". Focused barley breeding research programs were put in place and these also benefited from input from grain handlers, grain authorities, marketing organizations, brewers and malsters. The result was the release of a significant number and quality of new varieties of feed and malting barley from six state-based barley breeding programs.[45]

The GRDC funds national variety trials and state governments fund agronomic trails to ensure producers have an unbiased source of knowledge required to make good variety selection decisions.

[43] This spillover issue of less information and germplasm sharing was identified in the Australian system in Russell Thompson, "*The Yield of Variety Protection*" Amer. J. Agr. Econ. 97(3): 762-785 (2014).

[44] Poulsen D and R Lance, "Australia", in Ulrich, "Barley: Production, Improvement, and Uses", 2011

[45] Poulsen D and R Lance, "Australia", in Ulrich, "Barley: Production, Improvement, and Uses", 2011

Prior to 2006 the breeding programs operated by the states were funded at 60% to 65% by the states and the remaining 30% to 35% by the commonwealth.[46] In 2006, Barley Breeding Australia (BBA) was established "*as the Australian national barley breeding program implementing a national plan for breeding improved varieties to benefit the barley industry*." The six former barley programs were rationalized into one national program which had three nodes; one in the north (with Queensland Department of Primary Industries), one in the south Australia (with the University of Australia), and the other in the west (with the Department of Agriculture and Food, Western Australia)). The other three former programs were refocused to work on pre-breeding and germplasm development (the industry goods).

The BBA was an unincorporated joint venture between the GRDC and the state departments of agriculture, governed by an advisory board (of its members). There was also a management committee to coordinate activities.[47] During the BBA era, barley breeding was funded by states, the commonwealth, EPR's and by in industry contributions. The level of funding was about $12 M.[48]

In 2009, the GRDC examined the economic impact of investing in barley breeding. It looked at the impact of 22 new varieties released from 2002 to 2008 relative to the dollars invested ($25.5 M by the GRDC and $42.6 M by host organizations). The analysis found that the internal rate of return to the GRDC investment was 21.8% and the benefit cost ratio was 8.18.[49]

In 2011, the structure of barley breeding changed again. According to Barr and Moody, the following factors drove the change:[50]

- Slowing rate of genetic gain in cereals;
- Perceived advantages of privatized breeding entities;
- Competitive neutrality policy;
- Withdrawal of funds for ag research by State Governments; and
- Plant Breeders Rights and enhancements – EPRs.

BBA was terminated on June 30, 2011 and barley breeding followed the path of wheat breeding. Pre-breeding and R&D, funded by GRDC and states, remained the responsibility of the public domain. It was believed that this structural change would allow breeders and growers to respond to the needs of end-users. After the termination of BBA, university breeding programs received some transitional assistance from the GRDC [51].

Post BBA, in West Australia, the barley program was acquired by Intergrain (GRDC 25%, Department of Ag and Food West Australia 49% and Monsanto 26%) [52]. In South Australia, the University of Adelaide and the GRDC reached an agreement in 2013 which involved a $10 M investment over five years by the university.[53] The university restructured its very successful program into a for-profit business which will be funded by royalties. The GRDC no longer funds barley research at the university. [54]

At the same time, four regional Barley Advisory Committees were established to represent grower and breeder interests. Producers also have input to the development of new barley varieties through the GRDC.

[46] Intergrain, "Barley Breeding – The Challenges".
[47] Poulsen D and R Lance, "Australia", in Ulrich, "Barley: Production, Improvement, and Uses", 2011
[48] Intergrain, "Barley Breeding – The Challenges".
[49] GRDC, "*An Economic Analysis of GRDC's Investment in Barley Breeding*", 2009.
[50] Barr A and D Moody, "*The Evolution of the Organization and Funding of Barley Breeding in Australia*".
[51] Intergrain, "Barley Breeding – The Challenges".
[52] https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2011/02/Barley-Australia-update
[53] https://www.adelaide.edu.au/news/news63862.html
[54] *http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-109-Mar-Apr-2014/Barley-breeders-respond-to-industry-in-ferment*

The barley breeding sector has continued to evolve. Intergrain and Syngenta have established a partnership.[55] Intergrain has transformed from a regional barley breeder to a national breeder through partnerships with GRDC for northern barley breeding and with the Queensland Department of Agriculture, Fisheries and Forestry Queensland. [56] In March 2015, AGT (GRDC, Limagrain, South Australian Government and University of Adelaide) announced it was establishing a national barley breeding program. [57]

In 2015-16, end point royalties on barley range from $1/tonne on the variety Baudin developed by Intergrain when sold for feed (grower to grower sales are only allowed in West Australia) to $3.80/tonne on the University of Adelaide's variety Commander (grower to grower sales are not allowed).[58] In 2011, EPRs were predicted to provide about $7 M annually for barley.[59]

These changes to barley breeding are very recent, and it is too early to tell if producers have benefitted.

F.3 Uruguay

Uruguay is an example of another country that uses a royalty collection mechanism for reinvestment by plant breeders in variety development. Collection of royalties is on seed usage, whether a purchase of certified seed, or use of farmer saved seed. This is in contrast to an EPR system where collection occurs at the first point of sale. Capturing royalties on seed usage provides precise data on which varieties are planted.

Value Capture Using an Extended Royalty System

Uruguay ratified UPOV in 1994 (UPOV 1978 with some amendments from UPOV 91). Organizations involved in plant breeding include URUPOV (Uruguayan Plant Breeders Association) which was founded in 1994 and is focused on the collection of royalty and enforcement of PBR; and the National Seed Institute (INASE), which was created in 1997 and is the institute officially responsible for PBR.[60]

Royalty capture is high in Uruguay. Certified seed use represents approximately 50% of the seed sown. Because farmers using farmer saved seed (FSS) also pay a royalty, brown bagging (selling FSS or illegally obtained seed) is only on 5% of acreage. Figure F.2 indicates the extent of value capture in wheat.

[55] http://www3.syngenta.com/country/au/en/news/releases/Pages/Syngenta-InterGrain-Collaboration.aspx.aspx

[56] *http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-109-Mar-Apr-2014/Barley-breeders-respond-to-industry-in-ferment*

[57] http://www.ausgraintech.com/news.php?id=43

[58] www.varietycentral.com.au

[59] Intergrain, "Barley Breeding – The Challenges".

[60] International Seed Federation, "*Collection Systems for Royalties in Wheat, An International Study*", 2012.

Figure F.2 Area Planted in Wheat in Uruguay and Royalties Collected on Certified Seed

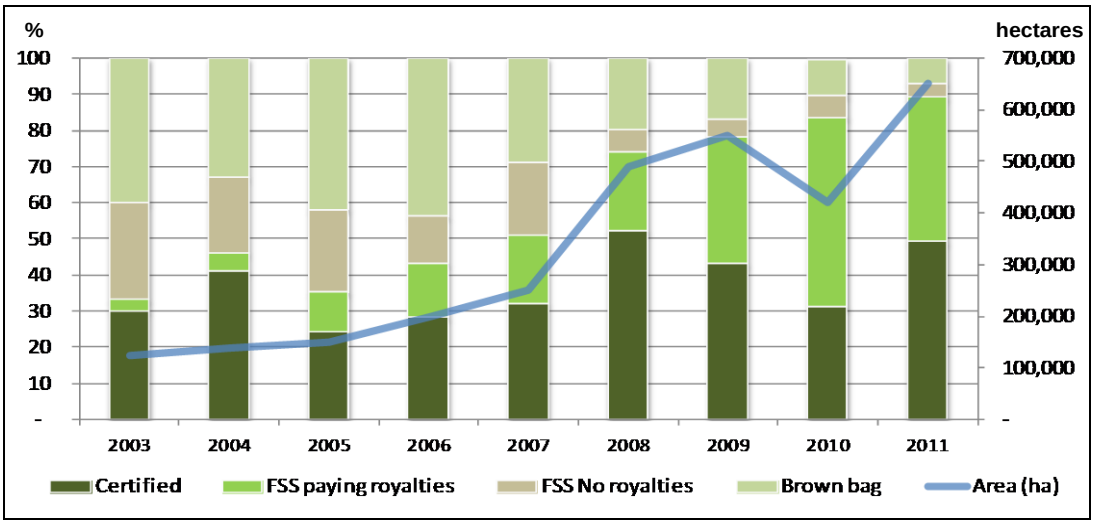


Fig. 6 - Development of the total area planted with wheat (ha) and royalties collected on certified seed and FSS (%).

Source: International Seed Federation, "*Collection Systems for Royalties in Wheat, An International Study*", 2012.

In 2011, 95% of the area was planted with certified seed or FSS with royalties. Since 2003, the Extended Royalty System/Technology Value System has been in place for soybean, barley, peas and wheat. Under this system, a contract is signed by the grower and the breeder when certified seed is purchased. The contract states the terms of FSS and production. The contract is renewed when the seed is multiplied or when seed is used for FSS. The royalty is due on the seed that is sown each year, whether saved seed or purchased as certified seed.

URUPOV has information on contracts, farmers, varieties, amounts etc. URUPOV auditors visit each farmer twice a year to obtain information and get a declaration signed; once after harvest (amount and location of FSS), and then again after seeding (amount of FSS seed sown)[61]. URUPOV then puts all the information in a database, and breeders invoice farmers for the royalties due.[62]

Farmers receive tax incentives to purchase certified seed. Since 2007 farmers are eligible for a tax deduction on certified seed (150% of seed cost). This helps to increase value capture. Enforcement of PBR and royalties is by INASE. URUPOV also has a team tracking brown bagging. To help identify infractions DNA fingerprinting and molecular markers are part of the enforcement tool box.[63]

Royalty collection is very efficient in Uruguay. Across all crops, certified seed use is 48% and legal FSS use is 44%. Thus royalties are paid on 92% of seed used. Breeders get 100% of the royalties due on certified seed. For FSS, there is a 7% collection cost. Thus overall efficiency is 89%. Factors behind the success of value capture include:[64]

- Farmers: follow PBR and pay royalties on FSS;
- Breeders: invest in new varieties;
- Government: provides a legal framework and enforcement;

[61] Anecdotal evidence suggests that in the case of wheat, 7 to 8 auditors visit approximately 500 commercial farms.
[62] International Seed Federation, "*Collection Systems for Royalties in Wheat, An International Study*", 2012.
[63] *ibid*.
[64] *ibid.*

- URUPOV: breeders work together;
- Multipliers & Distributors: communicate with farmers regarding PBR and collect information on FSS.

Royalty payments help fund variety development.

Agricultural Research &Development

Uruguay has a long history of agricultural R&D beginning in 1914 with the establishment of a breeding station (La Estanzuela). The time line from 1914 to 1989 is shown in Table F.1.

Table F.1 Time Line for Agricultural R&D in Uruguay

Year	Event
1914	Establishment of a plant breeding station, La Estanzuela, for wheat, flax, barley, corn, alfalfa and oats which became the leading cereal breeding institute in Latin America.
1932	Animal Biology Laboratory was established
1961	La Estanzuela became the CIAAB research station for crops and livestock. Its research mandate was expanded to include beef, dairy, sheep and pasture. It was very successful during the 1960's.
1973 to 1985	During this time a military dictatorship was in place. Very little funding for agricultural R&D was provided by the government, international donors, and lenders. Expertise left the country.
1975	National Fisheries Research Institute was established
1985	Military dictatorship ended. A review of the agricultural R&D system was held and INIA was established in 1989 from CIAAB (scope now also included forestry). A loan from IBD helped modernize stations and increase graduate level training.
1989/90	Establishment of the National Institute for Agricultural Research (INIA)

Source: Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008

In 1989 the National Institute for Agricultural Research (INIA) was established, the major player in agricultural research. Plant breeders in INIA receive some of their funding through any variety specific royalty payments.

In Uruguay, INIA "*conducts research, manages scientific knowledge and links with technology transfer*" [65]. There are about 20 entities conducting agricultural R&D. Besides INIA there are some other government agencies, non-profit agencies and higher education institutions conducting research. The breakdown of funding and research staff of INIA and the other non-profit groups is shown below In Table F.2 for 2006.[66]

Table F.2 Expenditures on Public Agricultural R&D and Researchers in Uruguay, 2006

	Research $ Share	Research Staff #	Staff Share
INIA	59.9%	142	35.6%
Other Government	13%	69.8	17.5%
Non-Profit Agencies	3.1%	17.2	4.3%
Higher Education Institutions	24.0%	170.4	42.7%
Total		399.4	

Source: Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008

[65] Byerlee D, "Producer Funding of R&D in Africa", paper presented at ASTI/IFPRI-FARA Conference, December 2011
[66] Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008

Crop research is the focus of INIA. In terms of crop research, the share by crop was as follows: fruit 33%; rice 15%; wheat 9%; barley 7%; other 5%; vegetables 16%; and potatoes 4%.[67] INIA conducts its own research and is required to provide 10% of its funding to external research organizations (mostly to universities). It receives about 60% of public spending on agricultural R&D.[68]

INIA receives the majority of its funding from the government and from a producer levy of 0.4% on sales by farmers of grain, milk, poultry, cattle, wool, unprocessed hides, pigs, and timber, and on fruit, vegetable, flower and seed exports.[69] The producer levy is collected at processor or marketing points. About 90% of the value of agricultural production is covered by the levy. In 2008, the levy raised $33 M US.[70] Levies collected are matched by the government.

From 1961 to 2010 spending on public agricultural research increased from $(US)1 M. to $(US) 39 M[71]. Spending on agricultural R&D is a function of the value of production. Uruguay has a very high agricultural R&D research intensity at 2% ($1.19 is invested by INIA for every $100 of agricultural output while $0.80 is invested by other government and non-profits and universities)[72]. Financing of government and non-profit agricultural R&D in 2006[73] was by the following:[74]

- Government 41%
- Commodity taxes and producer groups 33%
- Internally generated 16%
- Donors 4%
- Private Sector 0.1%
- Other 5%

Some information exists on allocation of research funding across commodities. In 1996, 43% of 399 researchers in 20 agencies worked on livestock; 25% on crops; 9% on fisheries; and 7% on post-harvest issues.

INIA has five regional experiment stations and has a four person board with two members from the government and two members from producer organizations. It allocates funds across programs and sectors. INIA is designed to listen and respond to producers and others. The regional stations each have a regional advisory council and technical working group (for each commodity or program) which provide input regarding priorities and technology design and transfer. INIA participates in 14 national roundtables.[75] INIA has collaborators inside and outside of Uruguay. It conducts joint R&D with external universities and agencies (NA, Europe and Oceania) and has ties with FAO programs, CGIAR etc. [76]

There has been some private research since 2000. Monsanto, Syngenta, and Pioneer have test fields for new varieties. Sometimes new crop varieties are first released in Argentina or Brazil and then evaluated in Uruguay. A Uruguayan brewery that did field trials for barley was the main private

[67] Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008
[68] Byerlee D, "Producer Funding of R&D in Africa", paper presented at ASTI/IFPRI-FARA Conference, December 2011
[69] Bervegillo J, J Alston and K Tumber, "The Economic Returns to Public Agricultural Research in Uruguay", Centre for Wine Economics, December 2011
[70] Byerlee D, "Producer Funding of R&D in Africa", paper presented at ASTI/IFPRI-FARA Conference, December 2011
[71] Bervegillo J, J Alston and K Tumber, "The Economic Returns to Public Agricultural Research in Uruguay", Centre for Wine Economics, December 2011
[72] Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008
[73] This does not include universities (and of course the private sector).
[74] Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008
[75] Byerlee D, "Producer Funding of R&D in Africa", paper presented at ASTI/IFPRI-FARA Conference, December 2011
[76] Stads G, B Cotro and M Alegru, "Uruguay", ASTI publication, 2008

sector firm doing R&D in the past. In addition, some private companies have done technology transfer and provided support/funding for R&D.[77] In the national registry there were 363 private cultivars of cereals, oilseeds, and forage in 2010.[78]

Impact of Agricultural R&D

Agricultural R&D spending in Uruguay compares very favourably to its neighbours as shown below.

Table F.3 Comparative Indicators of Research Spending, Uruguay and its Neighbours

Table 3. Comparative indicators of research spending and human resources, Uruguay and its neighbors

Indicator	Uruguay	Argentina	Brazil	Chile
R&D spending as a share of AgGDP, 2006 (%)	1.99	1.27	1.68	1.22
INIA budget as share of AgGDP, 2006 (%)	1.19	na	0.96	na
Percapita R&D, 2006 (2000PPP dollars)	15.61	7.61	6.81	6.45
Annual growth of government R&D spending, 1990–2006 (%)	3.65	2.61	–0.74	1.92
INIA operating budget as share of total budget, 2006 (%)	52	20	na	40
Spending per full-time equivalent researcher, 2006 (2000PPP dollars)	206	130	241	152
Share of INIA scientists with a postgraduate degree (%)	77	13	99	60
Share of INIA scientists with PhD degree (%)	32	na	77	na

Source: ASTI database and country briefs.

Note: INIA indicates Uruguay's National Institute for Agricultural Research.

Source: Byerlee D, "*Producer Funding of R&D in Africa*", paper presented at ASTI/IFPRI-FARA Conference, December 2011

Total factor productivity in Uruguayan agriculture was 3.9% from 2001 to 2010. Analysis indicates that the increase is strongly related to investments by government and producers and very weakly related to R&D by the private sector.[79] [80] An examination of the benefits and costs of public agricultural research in Uruguay over a 20 year time period found an internal rate of return of 23% to 27% per annum and a benefit to cost ratio of 48:1.[81]

An evaluation of INIA in 2011 found that:[82]

- It is effective. Total factor productivity growth is about 2% annually and many commodities have gained export share.
- The benefit to cost ratio for investment in public R&D was 16:1 to 20:1[83].
- Social and environmental impacts were good.
- There were positive impacts for wheat, barley and dairy but negligible for extensive livestock grazing.
- Technology transfer was weak (no formal system).
- Some management issues were identified.
- Rain fed crops may be underfunded relative to fruits, vegetables, rice and dairy. There is some free riding as not all fruit and vegetable growers pay the levy.

[77] Bervegillo J, J Alston and K Tumber, "The Economic Returns to Public Agricultural Research in Uruguay", Centre for Wine Economics, December 2011

[78] *Ibid.*

[79] Fischer, R. A., Byerlee, D., & Edmeades, G. O.. (2014*). "Crop yields and global food security: will yield increase continue to feed the world?"*. Canberra: Australian Centre for International Agricultural Research. Retrieved from http://aciar.gov.au/publication/mn158

[80] It is not clear how much or royalty revenues captured by the private sector are reinvested in Uruguay.

[81] Bervegillo J, J Alston and K Tumber, "*The Economic Returns to Public Agricultural Research in Uruguay*", Centre for Wine Economics, December 2011

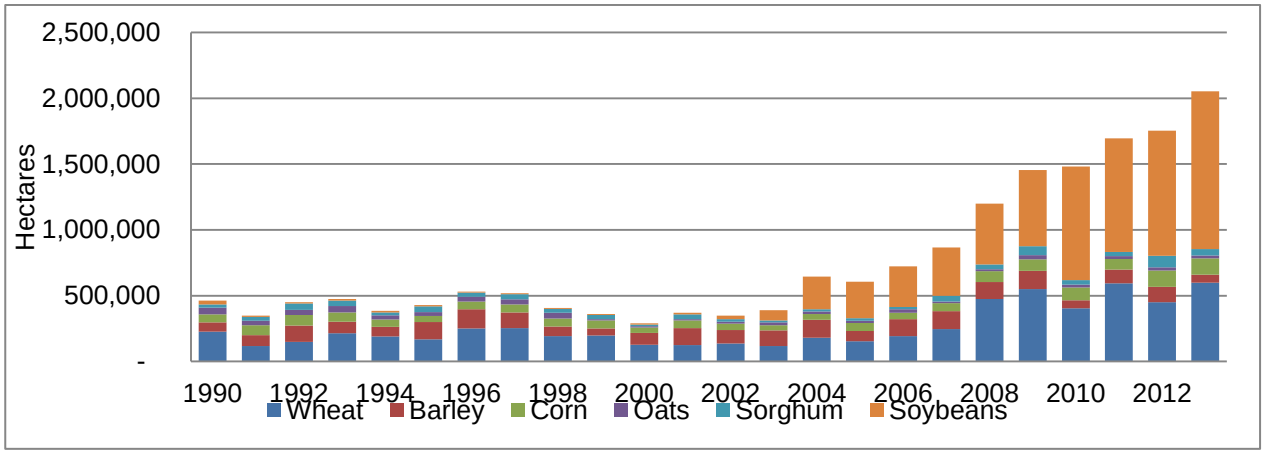
[82] Byerlee D, "*Producer Funding of R&D in Africa*", paper presented at ASTI/IFPRI-FARA Conference, December 2011

[83] This benefit to cost ration differs from the previously mentioned one due to different time periods and methodologies.

Crop Production & Exports

A number of factors have increased Uruguay's crop production and exports. In 2013, 0.6 M ha of wheat and 1.2 M ha of soybean were harvested. The area sown to soybeans (genetically modified) has increased dramatically since 2002 (see Figure F.3). The area devoted to other crops such as corn and barley is much lower [84]. Rain fed agricultural expanded during the 2000's because of 1) the introduction and adoption of zero tillage; 2) investment by Argentine companies in land which added capital, management and technology; 3) greater use of fertilizer; and 4) greater demand for forage and grain for livestock production.[85]

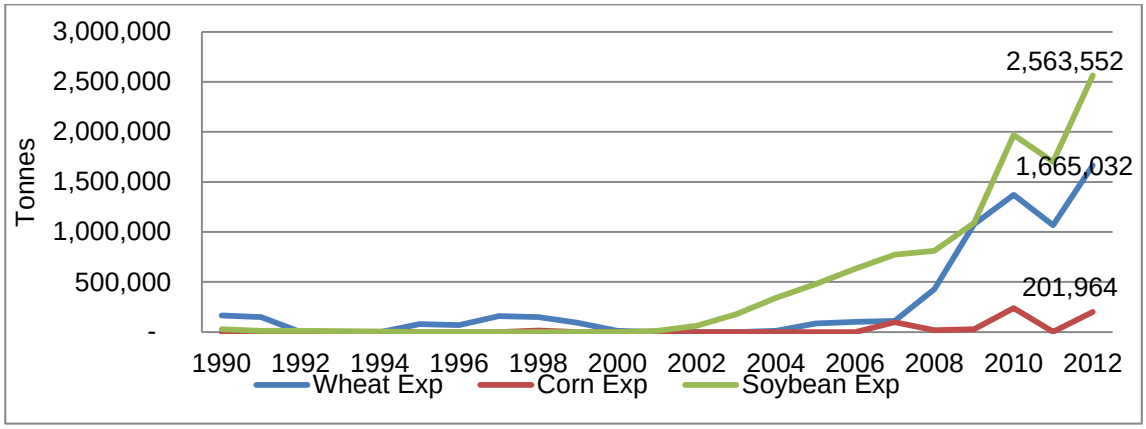
Figure F.3 Crop Acreage in Uruguay, 1990 to 2013



Source: FAO

The major export crop is soybeans with 2.6 M tonnes exported in 2012, compared to 1.7 M tonnes of wheat and 0.2 M tonnes of corn (Figure F.4). Wheat exports rose quickly after 2006. Soybean and wheat export volumes have increased as production expanded.

Figure F.4 Uruguay Exports of Corn, Wheat and Soybeans, 1990 to 2013



Source: FAO

Implementation of the Uruguay System in Canada

In Uruguay, INIA, the major publically funded research body is funded by a producer levy of 0.4% of sales value that is matched by government. In terms of capturing the value of IP on seed used by

[84] FAO

[85] Bervegillo J, J Alston and K Tumber, "*The Economic Returns to Public Agricultural Research in Uruguay*", Centre for Wine Economics, December 2011

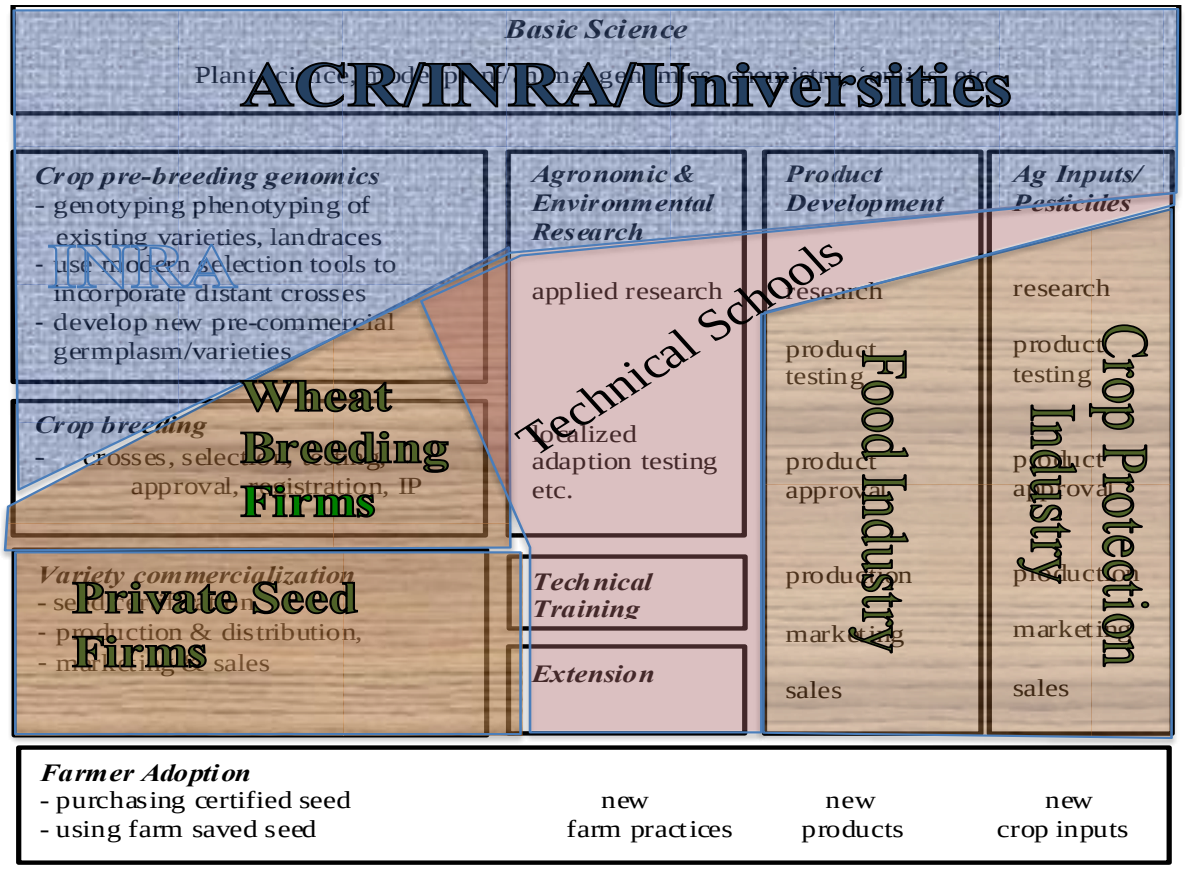
farmers, royalties are collected on varieties planted using either certified or farm-saved seed. Based on information collected on the farm, plant breeders invoice farmers for the royalty payment. If a similar system were implemented in Canada, funding by the federal government would be lower since public expenditures on variety development is between 0.5% and 0.6% of farm gate value in Canada, compared to the Uruguayan government matching of a 0.4% levy that applies to all research and development activities. As well, with a royalty system that is based on use of seed (as an input), versus the marketing of the output, producers would find the value capture system that has two yearly on-farm visits potentially rather intrusive.

F.4 Wheat Variety Development in France and Using a Uniform EPR System

The wheat breeding industry in France is characterized by mixture of public, private and producer organizations, operating in a well-financed, well-coordinated research system.

Figure F.5 provides an understanding of partnership roles in the French wheat innovation system. Notably, Institut National de la Recherche Agronomique (INRA[86]), and Universities undertake basic research and some applied research. Wheat breeding is largely a private activity, pre-breeding is a public activity with some private and producer participation.

Figure F.5 Overview of Institutions in Crop Research in France



Agronomic research and technical training is the domain of producer funded technical schools, while processing and crop protection inputs are largely private industry activities.

[86] Or National Institute for Agricultural Research

There are some learnings from France that can provide insight on producer involvement and funding of variety development using an EPR system[87]. Producers have limited involvement in wheat breeding in Europe, with the important exception of Limagrain headquartered in France, a very large successful producer owned cooperative.

INRA (Institut National de la Recherche Agronomique)

INRA was established in 1946 with the goal of "feeding France" focusing on farm production methods, crop and animal breeding. Over time, the research scope broadened to include food processing, biotechnology, environmental sustainability and the science has shifted to upstream research to support private breeding and applied research sector. In the last decade INRA has developed a wheat genomics program with the goal of supporting wheat breeding. It is now a very large agricultural research institution. At the end of 2012 INRA employed nearly 8,500 permanent staff in 18 regional centres, 13 scientific divisions and 6 metaprogrammes and had a budget of 881M€. INRA also ranks second in the world (behind USDA) in citations for publications in agricultural science[88].

INRA has approximately 200 staff permanent involved in wheat related research. This is made up of about 20 scientist and 180 technicians and an overall personnel and overhead cost of 20 million Euro per year (Feuillet, 2013). These resources make INRA France's dominant institution in pre-breeding research and put them in a lead position to collaborate with the private sector and international partners in wheat research projects.

Institutions Involved in France's Wheat Innovation System

France's wheat innovation system is heavily dependent on several key institutions that coordinate and create funding, and also depends on functional relationships between various firms and public organizations. Private firms also play a critical role in creating linkages and knowledge networks in France. Limagrain, the largest wheat breeder in France, is a producer run cooperative and plays a major role in many of the collective institutions.

Like many other countries France is making significant investments in the pre-breeding of wheat. Based on the development of genomics and biotechnology, the government of France made very large public investments, developing clusters, research consortiums and other projects with the private industry in France, and also taking a leadership role in some important international wheat research initiative.

Céréales Vallée Competitiveness Cluster

Much of the collaboration for pre-breeding wheat research is coordinated and funded through the Céréales Vallée, a very large and well-funded competiveness cluster. The cluster brings together a large number of firms from every part of the cereal supply chain, and a wide range of public institutions involved in various aspects of research, development and education. Céréales Vallée is only one of 71 innovation focused clusters created by a Les pôles de Compétitivité, a national program to improve the competitiveness of many sector of the France's economy, with a goal of investing 3% of the GDP on innovation.

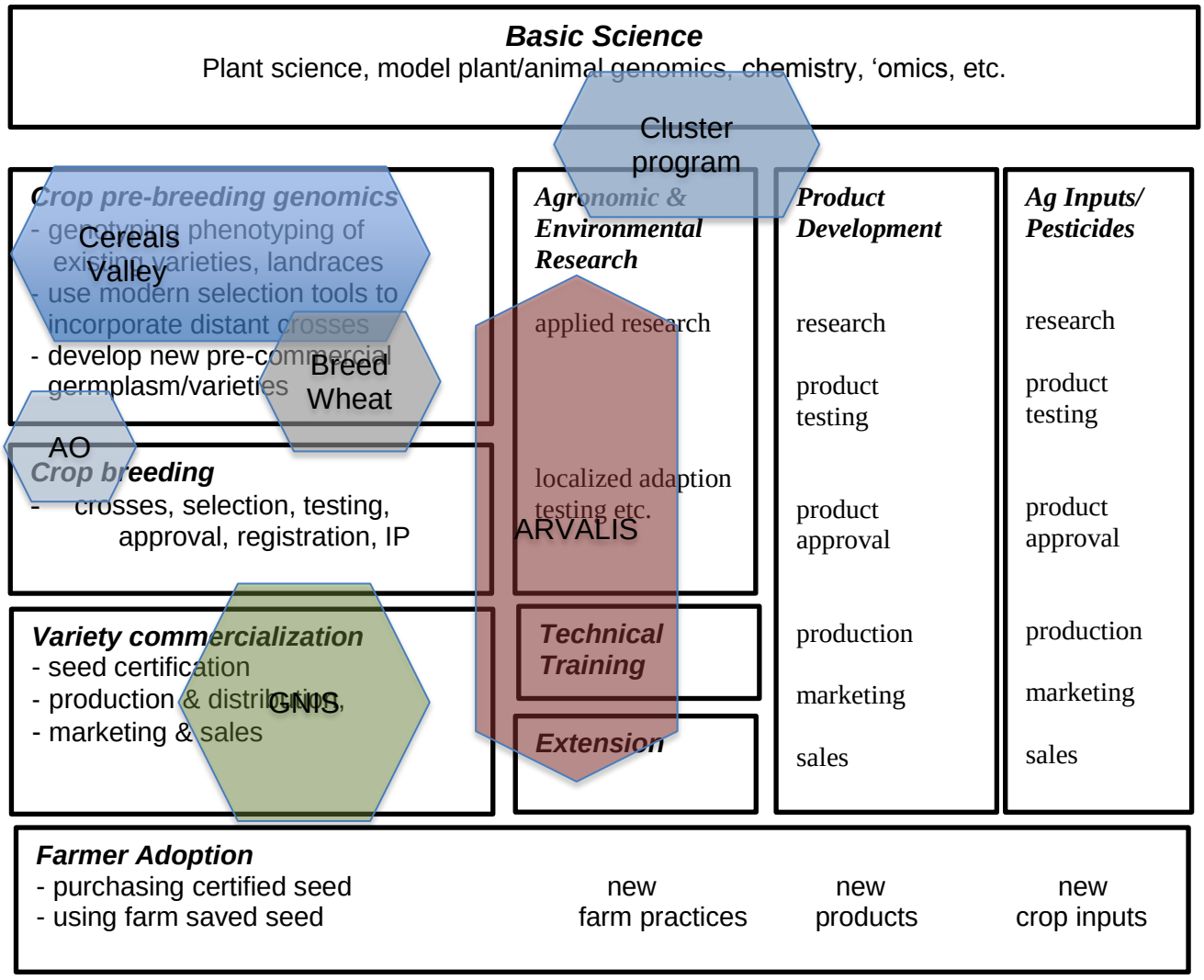
Céréales Vallée began in 2005 when IRNA, Limagrain, and the Agence Nationale Researche (ANR), answered a call for proposal by Les pôles de Compétitivité and proposed a cluster to enhance the competiveness of the cereal sector in France. The long history of collaboration between Limagrain and INRA made this a natural fit. "Céréales Vallée has 68 members and brings

[87] The source for this section includes (1) Richard Gray and Katarzyna Bolek. April, 2011. *Some International Successes in Funding Crop Research for Implementation in Canada*, CAIRN Policy Brief, (April 2011), and knowledge of members of the consulting team.

[88] (http://institut.inra.fr/en/Overview/Figures2).

together more than 500 participants, from the private and public sector, who are involved in research, industry, services and training related to cereal production." (Céréales Vallée, 2013). This breadth of membership allows members to identify opportunities for R&D that can improve competiveness anywhere in the supply chain. The cluster's mission is to developing research projects that will lead to innovation in farm production and/or innovation in product usage.

Figure F.6 Overview of Partnerships and Clusters in Wheat Variety Development



Céréales Vallée is a non-profit corporation governed by a the General assembly of its members. It has a 12 member Executive Council, and a 12 member science advisory board. The organization proactively solicits project ideas and facilitates project development for the benefit of members.

To date Céréales Vallée has been very successful in developing funded projects. Each project is funded is funded 25% with public funds through Les pôles de Compétitivité fundes, with the remaining 75% of each project coming from external funding. Since 2006, Céréales Vallée has funded projects with a total value of 340 M€ or 49 M€ per year. Approximately 2/3 of the projects are targeted toward enhancing grain production and 1/3 is focused on processed projects. Some of these projects are applied and focus on the development of a new product or process but some projects involve research and include *BreedWheat*, a large genomics per breeding project.

BreedWheat

The *BreedWheat* project is a long-term public-private research initiative coordinated INRA-GDEC. In total, 39 M€ (9 M€ of public funds) is being invested over 9 years by 26 French partners, including 11 private companies (ARVALIS-Institut du vegetal, RAGT, Bioplante, Biogemma, Limagrain Europe, Deprez, Syngenta, Agri Obtentions S.A., Momont, Caussade Semences, Bayer Cropscience, Secobra Recherches), to develop and use efficient genome sequence-based tools and new methodologies for breeding wheat varieties with improved quality, sustainability, and productivity. (INRA,2013).

The BreedWheat project aims to better characterize the wheat genetic resources available to the wheat breeders. This requires extensive genotypic and phenotypic analysis. One part of the program begins with adapted (close to commercial) wheat crosses and maps these populations, doing both genotypic and phenotypic analysis. Starting with these parent varieties should result highly selected genetic material by project end, which when crossed with an elite variety would be ready for a conventional breeding program.

The second part of the program, is more ambitious and is longer term in nature. INRA houses approximately 10,000 wheat varieties in their collection, ranging from exotic land races, older French varieties, to more modern varieties. From these 10,000 varieties, 5,000 will be selected for characterization using a chip analysis to find important genetic variation in these populations. The list of genetic markers uses for the chip analysis is provided by the consortium members.[89] After some core genotyping and phenotyping, *BreedWheat* members will select two panels of 250 lines. These lines will then be phenotyped in more detail. From these results, parental line will be selected for crossing and QTL populations.

The structure of *BreedWheat*, the use of proprietary markers, and sharing of the responsibility for selecting genetic material and phenotyping, suggests a true public-private partnership. The nine-year project life, which much longer than most public private partnerships, allows the consortium to do some path-breaking longer term applied genomics research. By utilizing new genomics tools and the extensive network of private phenotyping capacity to explore and utilize the rich genetic diversity of the wheat genome, the project has the potential leading to considerable longer term genetic gain.

Producer Involvement is Through Limagrain

Limagrain is the dominant seed company in France, and has grown to be the fourth largest firm (by seed sales) in the world and now operates in 39 countries. Limagrain's wheat variety *Apache* has been a dominant wheat variety in France for almost a decade reaching a peak market share of nearly 60 percent. Limagrain has an important international presence in vegetable seeds. In wheat, Limagrain operates breeding enterprises in many other countries, such as Brazil, Australia and the United States, and within a number of other European countries.

Despite is very large size, Limagrain is a producer owned cooperative, with 2,000 farmer[90] members from the Auvergne region of France electing the 18 farmer board members. The organization, which operates for the long run profitability of its members, has made many strategic investments and acquisitions since it began in 1964. Limagrain profited from a hybrid corn variety that had 40% of the French market for many years. The farmer board members also typically serve on the board of directors in the many joint ventures of Limagrain.

[89] To protect the identity of each marker, each marker will be given an alias e.g. L1, L2 for Limagrain. If these markers reveal some interesting traits, it is then up to get access to the marker directly from Limagrain.

[90] Only active farmers in the Auvergne region are eligible to be members of Limagrain. When farmer members retire or sell their land, their Limagrain shares are returned to the cooperative.

Limagrain has always been quick to build partnerships when they can see value in doing so. This openness allowed Limagrain to have a very close partnership with INRA and ARVALIS[91] over time. As the largest firm in the industry, Limagrain has been influential in developing a broad industry approach to development. As a founding member of Cereals Valley, Limagrain was proactive in expanding what had largely been their own public partnerships to create the research cluster and the multiyear BreedWheat genomics project.

INRA does much of the pre-breeding in variety development in France. As well, the Breedwheat consortium and the Cereal Valley cluster also participate in pre-breeding activities. The private sector, through these consortiums, recognizes the importance of pre-breeding activities.

Use of EPR in France

The French EPR system was established in July 2001 after an extended course of discussion among farmers, breeders and the government. The royalties are collected via an EPR known as Contribution Volontaire Obligatoire, (CVO), of value *0.70€,* (approximately *$1.10*) per tonne. The CVO is charged on the sale of all bread wheat at the time of delivery to a marketer. Once CVO is collected, "small farmers" who produce less than *90* tonnes (estimated to be less than 10% of all farms) can apply for a full rebate of the royalty. Farmers who bought certified seed can also apply and receive a refund of *20€,* (*$27.60*), per tonne of purchased seed.

After these rebates are paid, *85%* of the money raised by the levy is submitted to a property rights management organization for plant breeders '*Groupement National Interprofessionnel des Semences et des plants' (GNIS)*. This organization works with *'Société Coopérative d'Intérêt Collectif Agricole anonyme des Sélectionneurs Obtenteurs,'* (SICASOV), to allocate the royalties to breeders in proportion to each variety's individual share of certified seed sales. The remaining *15%* of the money raised by the CVO is used to support public wheat research[92].

The French royalty collection system has overcome a number of challenges that the Australian system struggles with. Five inherent advantages of the French system seem to be:

1. As the CVO applies to the sale of all wheat varieties, it is relatively simpler to administer;
2. The uniform rate for all varieties eliminates any incentives for producers to mis-declare varieties as there is no price difference;
3. The uniform royalty rate speeds up the adoption of varieties with better characteristics by putting these varieties on an the same price level as all existing varieties;
4. Following the idea from the third point, the EPR rates achieve compensatory levels even when prior varieties still exist in the market place;
5. Finally, since the EPR rate is negotiated between the seed industry and the farm leaders every three years, the system removes the risk that the concentrated industry will charge excessive royalty rates.

These characteristics suggest the uniform EPR rates system could be an attractive option for an EPR system in countries such as Canada. A seed trade representative for France indicated that a uniform EPR provided a level playing field for all seed developers.

France also has an a public institution called Agri-Obtentions that is responsible for commercializing crop varieties produced by IRNA, the National agricultural research agency. INRA undertakes applied breeding in crops where the private sector does not operate, which includes wheat varieties suitable for organic production. Agri-Obtentions is a crown corporation with a specific role of commercializing new varieties which includes variety testing, variety registration, and working with the seed industry for commercialization.

[91] ARVALIS is a technical institute that serves farmers.
[92] Talvas, J.L. based on a personal Interview by R. Gray February 2013, SICASOV, Paris, France

Implementing the French System in Canada

There are no producer cooperatives currently operating in wheat breeding in Canada. Given the very large scale of the private wheat breeding organizations it seems unlikely that a cooperative will be established anytime soon. One possible option would be to transform an existing non-profit corporation into some form of new generation cooperative or corporation where producers are purchasing shares through the levies paid to their provincial Commissions. The producer cooperative/corporation would then be in a position to partner with other organizations, and farmers would have an equity stake in the breeding program.

The creation of a Crown Corporation to handle the commercialization of AAFC cereal varieties, similar to Agri-Obtentions, could give the federal government, more flexibility in terms of governance and partnership arrangements. INRA researchers, with their focus on pre-breeding discovery research, recognize the value of having some breeding activities in their organization to make their research more relevant. Even though AgriObtentions is small, and limited to organic wheat varieties, this commercial window helps INRA understand the commercial perspective.

Cereal Valley and BreedWheat bring all public and private sector together. Knowledge sharing is part of the design. The private sector recognizes the value of public pre-breeding

With limited amount of breeding in INRA, educating breeders is difficult. Training is required through the university system

Implementing a universal EPR system in Canada would require a strong voice by producer organizations and the seed industry, and also the will of the federal government to pass supportive regulations.

F.5 Privatization of Wheat Breeding in the United Kingdom

In 1987 the UK government sold the publically funded Plant Breeding Institute (PBI) to Unilever, with the sale based on the presumption that it was not a government role to be involved in variety development. The assets acquired by Unilever became known as Plant Breeding International Cambridge (PBIC), which eventually became part of RAGT Seeds in 2004[93]. With limited royalty income split between six small private breeding programs and a lack of public pre-breeding research, yield growth in UK wheat stalled five years after the sale of PBI.

The experience in the UK provides a salient example of the risks to producers if they have a limited role in a public breeding system[94]. Twenty-five years have elapsed after privatization and, looking back, industry participants have almost unanimously agreed that the UK has lost 10-15 years of research capacity due to privatization. The transition from having a publically funded breeding system that provided basic discovery (i.e., pre-breeding activities) to a private breeding system incurred some difficulties, mostly due to a general decline in discovery research supporting variety development.

[93] It can be noted that Monsanto acquired PBIC in 1998 to further its development of hybrid wheat and GM wheats. When Monsanto decided to withdraw from GM wheat development, PBIC was sold to RAGT Seeds Ltd. (a producer owned seed company) in 2004.

[94] The information in this section is based on a study that used interviews of wheat scientists and breeders in the UK to highlight major developments in the UK wheat research sector following the privatization of crop breeding in 1987 and is contained in (1) V. Galushko and R. Gray. "*The Privatization of British Wheat Breeding: What Can Canada Learn?",* CAIRN Publication # 34. (2013) and (2) Viktoriya Galushko and Richard Gray, "*Twenty Five years of private wheat breeding in the UK; Lessons for other countries"* Science and Public Policy (2014) pp 1-15 doi:10.1093/scipol/scu004

Lessons from Privatization of the UK Wheat Industry

The privatization of wheat research in the UK provides six important lessons for countries that may be contemplating the privatization of public wheat breeding. The outcomes, policy changes, and responses that have occurred in twenty-five years that have elapsed since the sale of PBI provide tangible examples of the outcomes from privatization of wheat research, yielding lessons about measures that should be pursued and those actions that should not be repeated.

LESSON 1: *To create a private industry with the scale and scope to be internationally competitive either IPRs must be much stronger than the UK's 52.5% farm saved seed royalty, or additional funding mechanisms are required.*

The UK royalty collection system operates efficiently with coverage of more than 90% of the acres. Despite this extensive coverage, the pricing effect of the discounted farm saved seed royalty has kept royalty rates at low levels. The result is a very modest royalty stream generating $24 million in royalties, of which approximately $9 million being reinvested in breeding activities spread between six breeding firms. If other countries are to create privately financed intensive breeding systems, this will require either property rights with even higher royalty rates on farmer-saved seed or a producer levy system, or both.

LESSON 2: *Modestly sized private breeding industries require significant applied research support in order to be internationally competitive.*

The UK experience clearly illustrates that breeding firms with limited budgets cannot afford to make significant investments in plant science or crop science. While the UK government may have anticipated long-term public research savings, the recent level of reinvestment suggests that private breeding activities continue to require significant long-term public support.

LESSON 3: *If commercial breeding is removed from the public sector, mechanisms that maintain the linkages between applied public researchers and downstream breeding activities must be put into place.*

There is general view that the UK lost 10 to 15 years of wheat improvement by severing public researcher incentives to do applied crop science research. The UK learned the hard way that without incentives to do otherwise, competitively based science funding will attract public researchers toward activities with academic impact and away from applied research. If there are no clear incentives to work together, the links between producers, private breeders, and public scientists weaken. As these linkages become weaker the knowledge flow is impeded, thus further reducing the effectiveness of the upstream public science research. Fortunately, the UK also discovered programs that encouraged collaborative research and were quite effective in bringing public scientists and breeders together.

LESSON 4: *Government-mandated five-year funding blocks are a major impediment to long-term strategic research investments. Despite 25 years of post-privatization experience, the UK continues to lack a long term strategic plan for wheat innovation.*

In the last 13 years, the UK government introduced many new research funding initiatives (e.g., Wheat Genetic Improvement Network [WGIN], Long and Large [LOLA], Wheat Improvement Strategic Programme [WISP], Septoria tritici Blotch [STB], and others), each designed to foster wheat innovation. While these programs have brought much needed research resources to the sector, public researchers and the private breeders lamented the lack of a strategic plan and the inability to develop and fund long-term projects beyond the five-year commitment periods.

LESSON 5: *Mechanisms to enhance knowledge sharing are important. Therefore, transition planning should develop policies to reduce knowledge and research fragmentation.*

The sale of PBI and subsequent downsizing resulted in four small and two very small distinct breeding programs. Breeders' rights, mechanisms to share germplasm, genomics research, and other upstream knowledge provide efficient knowledge sharing and keep breeders on a level playing field.

LESSON 6: *Privatization of UK wheat breeding has made it more difficult to train crop scientists and crop breeders.*

The UK experience clearly illustrates that breeding and crop science are not a dichotomy. Good crop scientists need to understand breeding and breeders need to understand crop science. Although some training opportunities now exist, the removal of commercial breeding activities from public institutions make it more difficult to fund and train students with the knowledge of breeding and crop science. This suggests a need for the public sector to be involved in at least pre-breeding so that scientists get hands-on experience.

Annex G - Variety Development in the United States

This Annex has an overview of variety development in selected U.S. states where producers have some involvement in variety development. This overview begins with a brief explanation of plant utility patents and Plant Variety Protection in the US, and wheat and barley planted with public and private varieties. Following this, wheat and barley in selected states is overviewed.

G.1 Overview of Plant Protection and Variety Development

Intellectual Property Rights

In the US, the *Plant Variety Protection Act* (PVPA) was enacted federally in 1970 to protect the developers' intellectual property rights over new (non-hybrid) plant varieties that reproduce by seed. Under PVPA (1970), the breeder can chose to have PBR apply to a variety - it is a breeder's choice to seek PBR. Its purpose was to encourage the development of seed varieties for self-pollinating crops like wheat. Under the PVPA (1970) farmers were allowed to save seed and to sell seed to their neighbours subject to state law[95].

The PVPA was amended in 1994 and increased the period of protection to 20 years for crops such as wheat. As well, farmers could only sell farmer saved seed with the developer/owner's permission. In addition, all protected varieties have to be sold by name. The farmer exemption remained (i.e., right to save seed unless prohibited). There was also a research exemption.

Title V was an amendment to the *Federal Seed Act*. Under Title V seed must be sold by its variety name and can only be sold as certified seed. Seed certification is under state jurisdiction.

Developers of new varieties have two options under the PVPA:

1. Developers can sell certified or uncertified seed (this enables the developer to allow others to use the variety either free or for a fee); and
2. Under the "certification only" option seed can only be sold if it is certified (using Title V). Most varieties protected under PVPA are also protected under Title V.

Some seed developers protect their varieties with utility patents (granted by the US Patent and Trademark Office) instead. The patent prohibits the saving, cleaning/conditioning, or selling of the seed by farmers. Patents are typically used for biotech crop varieties. There are some wheat and barley varieties protected by utility patents, and there is no research exception under utility patent law.

Public vs Private

Acres and values for public and private varieties of U.S. wheat and barley for 2012 are shown in Table G.1. Public sector breeding programs are more important for wheat then they are for barley. The shares of production value grown using public varieties in 2012 for wheat and barley were 65% and 30%, respectively. One of the reasons why barley variety development is mainly in the private sector (at 70%) is the existence of large scale breeding programs supported by brewers such as MillerCoors and AB-InBev.

In the US public sector wheat and barley breeding is funded by USDA, state appropriations, commodity organizations, and by some private sector companies.

[95] Goeringer P, "*Understanding the Plant Variety Protection Act",* 2013 Agricultural Policy and Outlook Conference, 2013 and Morgan G and S Brown, "*The Plant Variety Protection Act: Information for Texas Small Grain Producers*", Texas A&M AgriLife Extension.

Table G.1 U.S. Public and Private Wheat and Barley Varieties, 2012

Item	Units	Wheat	Barley
Acres Planted Total	*million acres*	55.5	3.6
Acres Planted Public	*million acres*	33.8	1.1
Acres Planted Private	*million acres*	21.6	2.5
Public Acre Share	*%*	61%	31%
Private Acre Share	*%*	39%	69%
Value Total	*$ billion*	$17.8	$1.4
Value Public	*$ billion*	$11.5	$0.4
Value Private	*$ billion*	$6.2	$1.0
Public Value Share	*%*	65%	30%
Private Value Share	*%*	35%	70%

Source: USDA, "Addendum to 2013 TCAP Report Documenting Economic Impact of the Project"

USDA's Role in Plant Breeding

In cereal plant breeding, the USDA has two agencies that conduct plant breeding and/or research that directly supports plant breeding. These are the Agricultural Research Service (ARS), and Natural Resources Conservation Service (NRCS).[96] The ARS is primarily involved in the pre-breeding space to help the efforts of commercial breeders. ARS will, however, develop finished varieties for crops where there are no commercial breeders. The National Plant Germplasm System (NPGS) is a partnership between ARS and the National Institute of Food and Agriculture (NIFA), state experiment stations, and other stakeholders. Its primary objective is to maintain and build seed and plant gene banks and databases. Each year over 250,000 accessions are provided by the NPGS to educators, breeders, and researchers. The NRCS has a network of Plant Materials Centers (PMC) that select and test plants for conservation purposes.

According to an analysis by Wilson[97], public sector funding of wheat in the U.S. was $36 M in 2007 compared[98] to $22 M in 1998. Public sector funding of barley breeding was $10 M in 2007 compared to $6 M in 1998. While public funding for all wheat breeding rose, not all classes of wheat saw increased funding, as indicated in Table G.2.

Table G.2 Public Sector Funding of Wheat Variety Development by Class

Wheat Class	1998	2007
Hard Red Winter	$11.2 M	$8.6 M
Hard Red Spring	$1.9 M	$6.2 M
Soft Red Winter	$1.9 M	$2.5 M
Soft White Winter	$1.2 M	$3.7 M
Hard White Winter	$1.5 M	$4.4 M
Hard Amber Durum	$0.3 M	$1.1 M

Source: Wilson W, "*Research Funding Systems for US Wheat Research*", Presentation at Canada Grains Council Annual Meeting, April 2009

[96] USDA, "USDA Roadmap for Plant Breeding", March 2015.
[97] Source: Wilson W, "*Research Funding Systems for US Wheat Research*", Presentation at Canada Grains Council Annual Meeting, April 2009
[98] In a relative sense, such as per tonne or per acre, public funding of wheat variety development in the US is less than in Canada.

US Wheat Production by Class

In the US, hard red winter wheat accounted for 53% of acres, 35% of production and 36% of production value (in 2013/14). As shown in Table G.3 hard red winter is the dominant wheat class. Hard red spring wheat in comparison represented 19% of acres, 23% of production and 23% of value. Soft red winter wheat was just slightly below hard red spring's share of acreage but above hard red spring in terms of production share and value share. Durum accounted for only 2% of acres and 3% of production and value. This snapshot helps to explain why the development of some classes of wheat is primarily a public sector (USDA and university) activity. Smaller acreages are typically not supported by private sector seed companies.

Table G.3 Overview of 2013-14 US Wheat by Class

Item	Planted acreage *(M. acres)*	Harvested acreage *(M. acres)*	Production *(M. bushels)*	Yield *(bu/acre)*	Farm price *$/bu*	Value of Production *$ million*
Hard Red Winter	29.7	20.4	747.4	36.6	$7.03	$5,254
Share of Total	53%	45%	35%			36%
Hard Red Spring	10.9	10.7	490.6	45.8	$6.73	$3,302
Share of Total	19%	24%	23%			23%
Soft Red Winter	10.0	8.9	568.5	63.7	$6.53	$3,712
Share of Total	18%	20%	27%			25%
White	4.2	4.0	270.5	68	$6.85	$1,853
Share of Total	7%	9%	13%			13%
Durum	1.4	1.3	58.0	43.3	$7.46	$433
Share of Total	2%	3%	3%			3%
All Wheat	56.2	45.3	2135.0	47.1	$6.87	$14,667

Source: http://www.ers.usda.gov/data-products/wheat-data.aspx

In 2014, US farmers planted 56.2 M acres of wheat. The top two states in terms of acreage were Kansas (9.6 M acres) and North Dakota (8.0 M acres).[99] Producer involvement in these states is examined, as well as for Nebraska in following pages.

US Barley Production

The share of US barley used for malting purposes has increased. In 2012, 57.3% of all barley was used for malting versus 21.8% in 1986. The shares of barley used for feed has fallen to 30.7% in 2012 versus 51.1% in 1986. Over the same period, barley exports have fallen (from 22.7% to 4.6%) while barley used for seed and food has risen.[100] Because of the importance of malting barley, most of the variety development is focused on malting barley.[101]

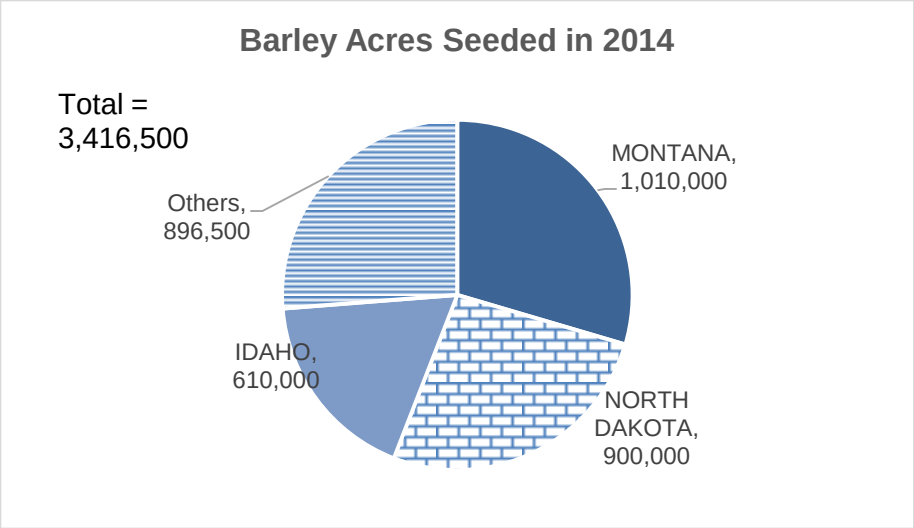
There are 15 malting variety development programs in the US; two USDA facilities; nine universities; two brewers; one malster; and one private sector seed company. They are as follows:[102]

- USDA:
  - USDA-ARS, Aberdeen Idaho
  - USDA-ARS, Raleigh, North Carolina

[99] USDA, NASS, "Crop Production 2014 Summary", January 2015.
[100] In 2012, the shares of barley used for seed and food were 3.8% and 3.6% respectively. In 1986 the shares of barley used for seed and food were 3.1% and 1.3% respectively.
[101] According to Horsely and Hochhalter, NDSU allocates 90% of its effort to malting varieties and 10% to feed varieties while the University of Minnesota allocates 95% of its efforts to malting varieties and 5% to feed varieties. (Horsely R and M Hochhalter, "*Overview of Midwest Spring Barley Breeding Programs*")
[102] Heisel S, American Malting Barley Association, "*The Future of Malting Barley in North America*", 2014.

- Universities:
  - Montana State University
  - North Dakota State University
  - Oregon State University
  - University of California – Davis
  - University of Minnesota
  - University of Nebraska
  - Utah State University
  - Virginia Polytech & State University
  - Washington State University
- Brewers:
  - AB-InBev
  - MillerCoors
- Malsters:
  - Malteurop
- Seed Companies:
  - Limagrain

In 2014, 3.4 M acres of barley were seeded in the US. As shown below, the largest acreages were in Montana (30% of total), North Dakota (26% of total), and Idaho (18% of total).



This study examined producer involvement in barley variety development in Montana, North Dakota, and Idaho because these states had the largest acreages. Oregon, based on comments from the Working Group, is also examined.

G.2 Wheat Variety Development in Kansas

Kansas wheat farmers are significantly involved in the development of new varieties through the Kansas Wheat Commission (KWC); Kansas Wheat Alliance (KWA); Heartland Plant Innovations; and the Kansas Wheat Commission Research Foundation. Some of these are P3 and some are P4.

- Kansas Wheat Commission: Established in 1957 the commission currently has a voluntary assessment of 2 cents/bushel ($0.75/tonne). In 2013/14 the KWC collected $5.3 M and refunded $207,000. Just over $1 M was spent on research.[103]

- Kansas Wheat Alliance (KWA): A partnership between the KS Association of Wheat Growers and the KWC which was established in 2007. "*The Kansas Wheat Alliance was founded by Kansas wheat producers, seedsmen, and researchers to strengthen the wheat industry by creating a variety delivery system that promotes stewardship of varieties and traits, provides new funds for wheat research, and ensures availability of improved wheat varieties to benefit farmers and consumers*." The KWA allows producers to obtain traits that it wants such as Clearfield[104]. The not-for-profit organization manages the release of varieties from Kansas State University (KSU) inside and outside of Kansas. KWA receives royalties of $0.90/bushel (or $33/tonne) of certified seed. From 2009 to 2012, the KWA received $2.2 M in royalties.

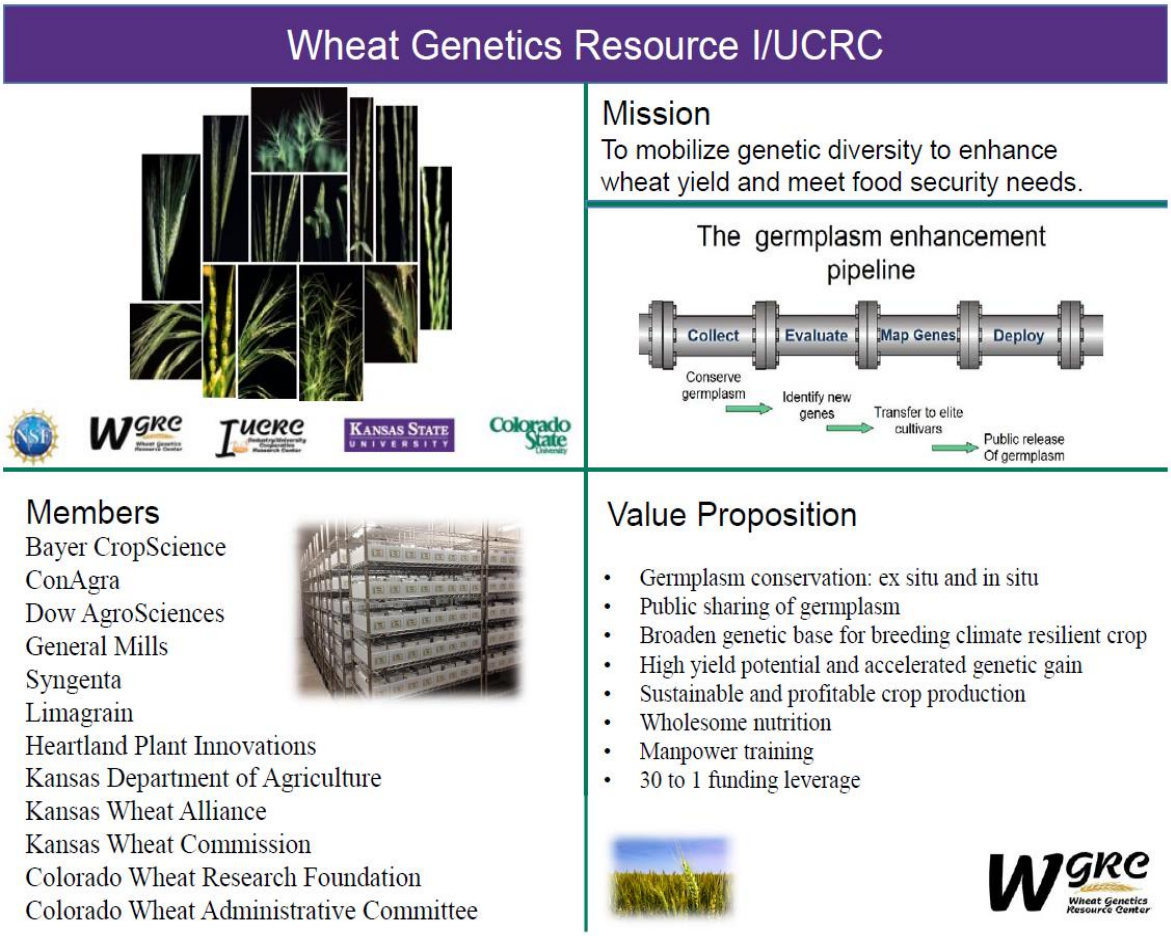
- One of the major initiatives of the KWA is the establishment of the KS Wheat Innovation Center, a $10.3 M investment funded primarily through wheat checkoffs[105]. The Wheat Innovation Center has 35,000 square feet of space (laboratories, greenhouses, and offices), and is home to a wheat genetic bank. The KSU Wheat Genetics Resource Center (WGRC) objectives are to 1) "collect, conserve, and utilize germplasm in crop improvement for sustainable production by broadening the crop genetic base"; 2) "create and promote the free exchange of materials, technology, and new knowledge in genetics and biotechnology among the world's public and private organizations"; and 3) "sponsor graduate and postgraduate students and visiting scientists for academic training and advanced research in the WGRC laboratories".[106] Wheat germplasm was collected over a 30 year period and has been used in breeding programs in 39 states and 45 countries.[107]

- The National Science Foundation has funded a public/private consortium (Wheat Genetics Resource Center (WGRC)/Industry/University Cooperative Research Center (I/UCRC) to enhance wheat yield through genetics). Members include the following:[108]
  - Wheat Genetics and Genomics Resource Center
  - Kansas Wheat [109]
  - Bayer Crop Science
  - Limagrain Cereal Seeds
  - ConAgra Foods
  - General Mills
  - Dow Agro Sciences

[103] Kansas Wheat Commission, "Annual Report", 2014.
[104] http://kswheatalliance.org/about/
[105] Gilpin J, "*Kansas Wheat Research Update*".
[106] http://www.k-state.edu/wgrc/
[107] Gilpin J, "*Kansas Wheat Research Update*".
[108] http://kswheat.com/news/2013/08/19/nsf-iucrc-wheat-genetics-resource-center
[109] Kansas Wheat is the name of the cooperative agreement between the Kansas Wheat Commission and the Kansas Association of Wheat Growers regarding investment in wheat genetics research.

- Heartland Plan Innovations
- Earth's Harvest
- Syngenta
- Kansas Wheat Alliance
- Colorado Wheat Research Foundation
- Colorado Wheat Administrative Committee
- National Science Foundation
- U.S. Economic Development Administration
- USAID
- Kansas Department of Agriculture
- U.S. Department of Agriculture
- Pioneer/DuPont
- Agricultural Research Center
- Washington Wheat Commission
- Oregon Wheat Commission
- Idaho Wheat Commission

More information about this partnership is shown below.



Source: National Science Foundation, "*The Industry/University Cooperative Research Centers Program, 2014 Annual Meeting*"

- Heartland Plant Innovations: This for-profit company established in 2009 does contract research services. The majority shareholder is KS Association of Wheat Growers. Other partners are as follows:[110]
  - Kansas Bioscience Authority
  - Kellogg Company/Kashi
  - General Mills International
  - Caravan Ingredients
  - Pioneer Hi-Bred
  - Monsanto
  - Individual Producers
  - ConAgra Foods
  - Kansas State University
  - University of Kansas
  - Colorado Wheat Research Foundation

- Kansas Wheat Commission Research Foundation: Established in 2011 to fund research, it is governed by a volunteer board. Gifts to the foundation are tax deductible. In 2013, ADM and KS State Agricultural Research Station at Hayes established a five year $325,000 partnership to improve hard white wheat varieties via doubled haploid and marker assisted selection.[111]

Wheat is important to the Kansas economy and it is not surprising that more than one economic analysis of wheat breeding in Kansas have been conducted. Barkley estimated the economic impact of wheat breeding by KS Agricultural Experiment Station funded by the state, KWC, and USDA from 1978 to 1996. He found a benefit/cost ratio of almost 12 and an internal rate of return of 39%.[112] Another study found that the benefit/cost ratio of public wheat breeding in Kansas from 1977 to 2006 was 17.6. [113]

Prior to the development of Heartland Plant Innovations an economic analysis was conducted to estimate feasibility. The facility would employ doubled haploid technology which would reduce the time required to develop a new wheat variety and thus speed up the rate of genetic gain in yield. This technology can replace the propagation component reducing the average development time from 11 years to 7 years. Barkley and Chumley looked at the insertion of a doubled haploid program into public wheat breeding for Kansas. The results shown below indicated that the business should benefit Kansas wheat producers (e.g., under the baseline scenario, double haploid technology has a benefit to cost ratio of 11.2 and a 33.4% internal rate of return, resulting from eliminating 4 years of development time).[114]

[110] http://www.heartlandinnovations.com/about-us/partners
[111] http://kswheat.com/news/2015/05/14/adm-and-k-state-celebrate-continued-partnership
[112] USDA, ERS, "*Using Economic Surplus Analysis to Estimate the Rate of Return to Kansas Wheat Breeding*", 2010.
[113] Nalley L, A Barkley and F Chumley, "*The Impact of the Kansas Wheat Breeding Program on Wheat Yields*, 1911-2006", Journal of Agricultural and Applied Economics, 2008.
[114] Barkley A and F Chumley, "*A Doubled Haploid Laboratory for Kansas Wheat Breeding: An Economic Analysis of Biotechnology Adoption*", International Food and Agribusiness Management Review, Volume 15, 2012.

Table 4. Model Results: Variety Development Time.

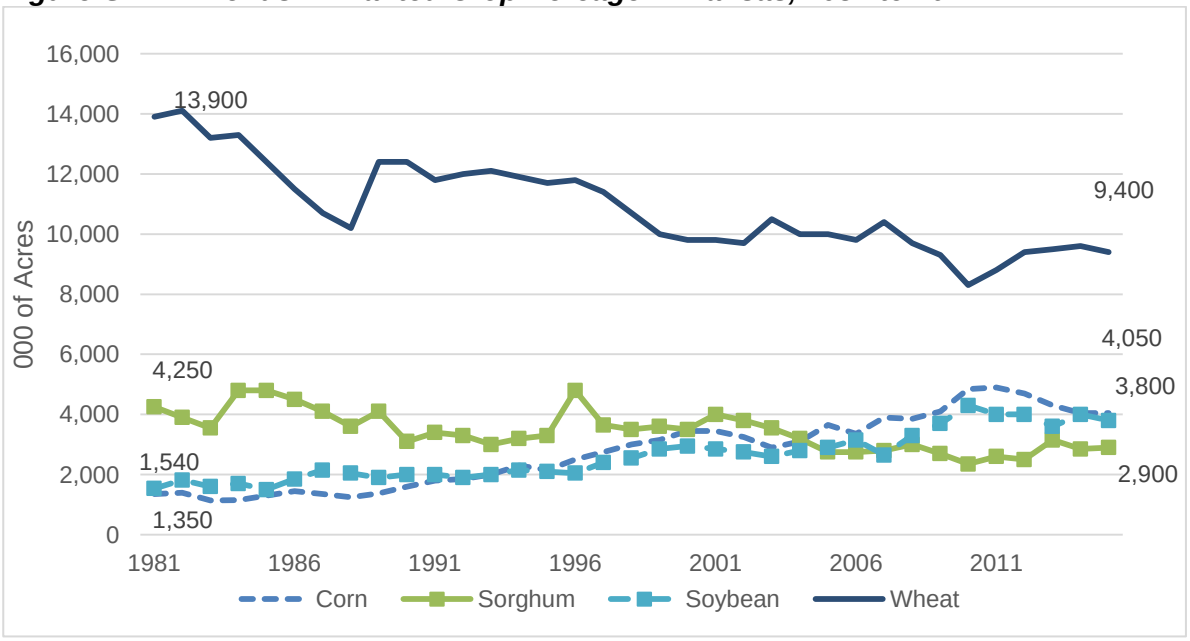
	Scenario		
	Short	**Baseline**	**Long**
Conventional	8	11	12
Doubled Haploid	6	7	9
Net Present Value (NPV)[1]	155.091	173.286	125.234
Benefit Cost Ratio	10.169	11.245	8.404
Internal Rate of Return	0.341	0.334	0.267

[1] Values are in million 2010 USD, and the assumed discount rate is ten percent.

Source: Barkley A and F Chumley, "A Doubled Haploid Laboratory for Kansas Wheat Breeding: An Economic Analysis of Biotechnology Adoption", International Food and Agribusiness Management Review, Volume 15, 2012.

Wheat acreage in Kansas fell from 13.9 M acres in 1981 to 9.4 M acres in 2015. Sorghum acres also fell. From 1981 to 2015, corn and soybean acres increased at an average annual rate of approximately 3%.

Figure G.1 Trends in Planted Crop Acreage in Kansas, 1981 to 2014



Source: USDA, NASS

The top ten varieties of wheat seeded in Kansas for 2015 are shown below along with developers and IP. The top varieties are hard red winter. The public varieties within the top ten represented 34.2% of total acres. The share represented by public varieties has fallen over time. According to Nalley et al, in 1977 public varieties had a much larger share at 98% of acreage.[115] Kansas State University has released over 40 wheat varieties since the early 1990's. It currently has two wheat breeders. Syngenta has a large wheat research station at Junction City.

[115] Nalley L, A Barkley and F Chumley, "*The Impact of the Kansas Wheat Breeding Program on Wheat Yields, 1911-2006*", Journal of Agricultural and Applied Economics, 2008

Table G.4 Top Ten Wheat Varieties in Kansas, 2014

Variety	Share of Seeded Acres in 2015	Developer	US IP	Type
Everest	16%	KSU	PVP94	**
TAM 111	9%	TX AES	PVP94	**
T158	5%	Limagrain	Not Protected	
WB Cedar	5%	Monsanto	PVP94	*
TAM 112	4%	TX AES	PVP94	**
Winter Hawk	4%	Monsanto	PVP94	*
Armour	3%	WestBred/Monsant	PVP94	*
Duster	2%	OAES	PVP94	**
Denali	2%	CO WRF	PVP94	**
Endurance	2%	OAES	PVP94	**
SY Wolf	1%	Syngenta	PVP94	**
Total Seeded Acres	**9.4 Million**			

Note: "**" indicates that the seed is to be sold by variety name and only as a class of certified seed and unauthorized propagation prohibited; "*" indicates unauthorized propagation prohibited, and "AES" refers to Agr. Experiment Station, "OAES" refers to Oklahoma Ag Experiment Station, and "CO WRF" refers to Colorado Wheat Research Foundation.
Source: USDA, "Kansas Wheat Varieties", February 2014; 2014 Kansas Wheat Seed Book; and http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl?

Outcomes of Partnerships

The P4 Heartland Plant Innovations is expected to be beneficial according to the economic analysis. A barrier to entry in cereal breeding is the cost of innovation. Heartland Plant Innovations is reducing the cost of innovation for both public and private wheat breeders. Reducing the time to market increases the rate of increase in yield, which benefits producers.

The P4, Wheat Genetics Resource Center (WGRC)/Industry/University Cooperative Research Center (I/UCRC) is working in the genomics area and creating human capital. Both of these benefit the public and private sectors.

Implication for Canada

There is a role for P4s in wheat breeding. Partnerships that result in reductions in the time to market benefit private and public breeders. Producers gain through faster yield growth (arising from lower innovation costs and improved time to market). Partnerships in pre-competitive areas (such as genomics) benefit the public and private sectors. Producers gain through access to better varieties. Producers in Canada could be proactive about seeking out technologies that could benefit them, and then have the private or public sector further develop these technologies for the benefit of the industry.

The Kansas Wheat Alliance, a partnership, licenses traits that are of benefit to producers from the private sector (Clearfield). KSU then develops varieties with the trait (in progress). In Canada a similar case occurred. Clearfield lentils were the result of a P4 between the CDC, BASF and Saskatchewan Pulse Growers.[116]

[116] https://www.realagriculture.com/2012/06/the-success-of-clearfield-lentils-in-western-canada/

G.3 Wheat Variety Development in North Dakota

Information regarding wheat variety development at North Dakota State University (NDSU) is shown below in Table G.5. In terms of research intensity, the development of hard red spring and durum varieties appear to be higher than for the winter wheat programs. Most wheat acreage in North Dakota is planted to spring wheats.

In 2012, NDSU and Monsanto made an agreement to share resources, wheat genetics and wheat breeding tools. Declining wheat acres, changing technology, and federal support were cited as the largest reasons behind the agreement. NDSU believes that the agreement will result in more varietal choice for ND producers (seems to be focused on hard red spring wheat).[117] Information on varietal spending was not available.

Seed is certified in North Dakota by the North Dakota State Seed Department. It is also responsible for collecting royalties due on varieties developed by NDSU, U of M, SDSU, and Busch Agricultural Resources.[118]

Table G.5 Wheat Breeding at NDSU

Class	# Breeders	# Varieties Released
Hard Red Spring	1 breeder	51 varieties released since 1892 11 varieties released from 2003 to 2013 10 germplasm/recombinant inbred lines released since 2004
Durum	1 breeder	44 varieties released since 1908 5 varieties released since 2005
Hard Red Winter	1 breeder	8 varieties released since 1977 4 varieties released since 1998
Hard White Spring	Same as HRS	1 variety released since 1998

Source: http://www.ag.ndsu.edu/plantsciences/research

Wheat Varieties Grown in North Dakota

USDA conducts an annual survey of wheat varieties grown in in North Dakota. The top spring wheat varieties grown in 2014 were Barlow, Prosper, SY Soren, Faller, and Glenn accounting for 55% of acres. Table G.6 also identifies the developer, IP and type of IP, and whether research fees are due to university developers (indicated in the last column). Varieties developed by NDSU and listed by name accounted for 47% of total spring wheat acreage. Public varieties (developed by universities) listed by name accounted for 60%. Private sector varieties listed by name accounted for 24% (Monsanto and Syngenta). Other private sector companies with varieties include Croplan, Limagrain, and Meridian (are in the other category). Almost all of the varieties shown below are protected under Title V and the PVPA 1994 (indicated by **) with the remainder protected under the PVPA 1994 (indicated by *).

Similar information for durum varieties in North Dakota is provided in Table G.7. The top three varieties accounted for approximately two-thirds of total acreage in 2014. NDSU is the dominant developer; its named varieties represented 91% of total durum acreage in 2014. NDSU collects a research fee on four varieties. Most of the varieties shown below are protected under PVPA 1994 and Title V (indicated by **). There is one unprotected variety (DG Star is not classified as unprotected because it was developed by Dakota Growers Pasta and produced under contract).

[117] http://www.farmandranchguide.com/news/crop/ndsu-monsanto-wheat-agreement-may-reclaim-acres/article_44c399fe-fac1-11e2-a586-001a4bcf887a.html
[118] http://www.nd.gov/seed/field/index.aspx

Table G.6 Spring Wheat Varieties Planted in North Dakota

Variety	2010	2011	2012	2013	2014	2014 Acres	Developer	US IP	Type	Research Fees
	%	%	%	%	%	1,000				
Barlow	0.9	8.5	17.2	18	15.7%	924.8	NDSU	PVPA 94	**	Y
Prosper	-	-	2	8.8	11.7%	690.0	NDSU	PVPA 94	**	Y
SY Soren	-	-	2	9.2	10.5%	619.7	Syngenta/AgriPro	PVPA 94	**	
Faller	15	11.4	13.1	9	8.8%	517.8	NDSU	PVPA 94	**	Y
Glenn	25	18.1	14.4	10.1	8.2%	481.2	SDSU	PVPA 94	**	Y
WB Mayville	-	0.1	0.7	2.7	4.4%	258.6	Monsanto/Westbred	PVPA 94	*	
Brennan	1.9	5.4	4.9	3.8	3.2%	188.6	Syngenta/AgriPro	PVPA 94	**	
Mott	0.1	1.2	3.1	2.1	2.9%	171.7	NDSU	PVPA 94	**	Y
Elgin-ND	-	-	-	0.2	2.7%	159.1	NDSU	PVPA 94	**	Y
RB07	4.9	7	4.1	3.6	2.6%	151.4	U of MN	PVPA 94	**	Y
Kelby	6.4	5.4	2.6	4.3	1.9%	111.4	Syngenta/AgriPro	PVPA 94	**	
Vantage	1.1	3.5	5.5	2.8	1.9%	110.8	Monsanto/Westbred	PVPA 94	*	
Steele-ND	3.6	3.2	2.2	1.7	1.7%	97.5	NDSU	PVPA 94	**	Y
Rollag	-	-	0.1	0.8	1.5%	90.3	U of MN	PVPA 94	**	Y
Freyr	4.8	3.3	2.2	2.5	1.3%	77.7	Syngenta/AgriPro	PVPA 94	*	
Velva	-	-	0.1	0.4	1.3%	77.2	NDSU	PVPA 94	**	Y
Reeder	1.4	1.8	0.6	0.9	1.1%	65.7	NDSU	PVPA 94	**	
Jenna	1.1	3.1	3	2.5	1.1%	65.6	Syngenta/AgriPro	PVPA 94	**	
Select	-	0.2	0.7	1.7	1.1%	63.9	SDSU	PVPA 94	**	Y
Alsen	3	1.6	1.5	0.8	1.0%	59.2	NDSU	PVPA 94	**	
Unknown varieties	3.6	6.9	4.7	3.1	6.6%	386.6				
Other varieties	27.2	19.3	15.3	11	9.0%	531.2				
All varieties	**100**	**100**	**100**	**100**	**100%**	**5,900.0**				

Note: "**" indicates that the seed is to be sold by variety name and only as a class of certified seed and unauthorized propagation prohibited; "*" indicates unauthorized propagation prohibited, and "Y" indicates a research fee to the university system.
Source: USDA, NASS, ND Field Office, "*North Dakota 2014 Wheat Varieties*", July 2014 and http://www.nd.gov/seed/field_directory/cwht.asp

Table G.7 Durum Wheat Varieties, Planted in North Dakota

Variety	2010	2011	2012	2013	2014	2014 Acres	Developer	US IP	Type	Research Fees
	%	%	%	%	%	1,000				
Divide	26.6	32.5	30.4	33.4	37.0%	322.0	NDSU	PVPA 94	**	Y
Alkabo	9.5	11.7	14.7	19	16.2%	141.0	NDSU	PVPA 94	**	Y
Mountrail	12.9	13	13.3	12.7	12.9%	112.2	NDSU	PVPA 94	**	
Tioga	-	2.1	2.9	10.7	9.7%	84.1	NDSU	PVPA 94	**	Y
Lebsock	12.7	9.5	10.3	10.3	7.5%	65.1	NDSU	PVPA 94	**	
Grenora	7	6.2	10.2	2.3	3.4%	29.8	NDSU	PVPA 94	**	Y
Ben	4.6	2.9	1.3	1.5	1.6%	14.3	NDSU	PVPA 94	**	
Monroe	0.1	0.5	0.2	1	1.0%	8.4	NDSU	Not protected		
Dilse	2.8	0.6	1.3	1.5	1.0%	8.4	NDSU	PVPA 94	**	
DG Star	1.5	1.1	0.7	0.9	0.8%	6.6	Dakota Growers Pasta	No Info		
Pierce	7.9	2.8	3.4	1	0.7%	6.2	NDSU	PVPA 94	**	
Westhope	-	0.8	0.1	0.1	0.4%	3.4	Monsanto/Westbred	PVPA 94	*	
Unknown varieties	4.2	7	4.4	2.6	2.7%	23.8				
Other varieties	10.2	9.3	6.8	3	5.1%	44.7				
All varieties	**100**	**100**	**100**	**100**	**100%**	**870.0**				

Note: "**" indicates that the seed is to be sold by variety name and only as a class of certified seed and unauthorized propagation prohibited; "8" indicates unauthorized propagation prohibited, and "Y" indicates a research fee to the university system.
Source: USDA, NASS, ND Field Office, "North Dakota 2014 Wheat Varieties", July 2014 and http://www.nd.gov/seed/field_directory/cwht.asp

In 2014, the top winter wheat variety in terms of seeded acres was Jerry (an unprotected variety) which was developed by NDSU (see Table G.8). There is more diversity in terms of who developed the variety. The ability to transfer varieties geographically seems to be important in winter wheat. Just over 50% of the top varieties were developed by US universities. Varieties developed in Canada made up 10% of acreage in 2014. The varieties shown in the table are hard red winter varieties.

These tables demonstrate North Dakota State University (NDSU) varieties are acreage leaders. NSDU (with assistance from USDA) is the only entity breeding wheat in North Dakota. At one point Dakota Growers Pasta had its own durum breeder.

Table G.8 Winter Wheat Varieties, Planted in North Dakota

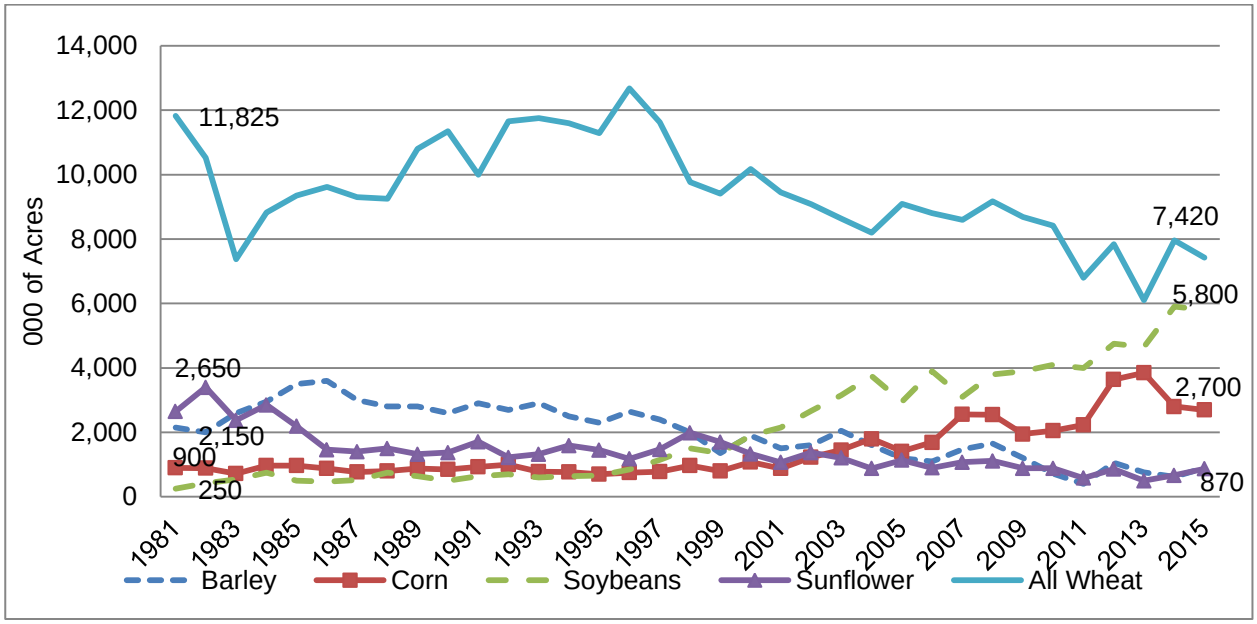
Variety	2010	2011	2012	2013	2014	2014 Acres	Developer	US IP	Type	Research Fees
	%	%	%	%	%	1,000				
Jerry	48.2	38.4	35	31.8	26%	204.7	NDSU	Not protected		
Decade	-	0.3	3.6	11.3	18%	140.7	MT State/NDSU	PVPA 94	**	Y
WB Matlock	-	0.7	2.4	3.2	7%	55	Monsanto/Westbred	PVPA 94	*	
Overland	4.2	4.5	6.6	5.1	6%	49.5	U of NL	PVPA 94	**	Y
SY Wolf	-	-	0.3	4.6	4%	31.8	Syngenta/AgriPro	PVPA 94	**	
Hawken	6.4	6.3	5.6	5.9	3%	26.9	Syngenta/AgriPro	PVPA 94	**	
Peregrine	-	0.6	2.1	2.6	3%	24.5	CDC			
CDC Falcon	12.2	10.8	10.8	4.6	3%	20.7	CDC			
Wesley	6.7	4.4	1.9	5.7	2%	19.9	U of NL/SDSU/WY	Not protected		
Boomer	-	0.6	3.8	2.7	2%	19	Monsanto/Westbred	PVPA 94	*	
CDC Accipiter	-	2.4	4.7	0.3	2%	17.2	CDC			
AC Radiant	0.6	1.4	1.3	1.3	2%	16	AAFC			
Unknown varieties	9	14.4	8	5.9	14%	114.2				
Other varieties	12.7	15.2	13.9	15	7%	59.9				
All varieties	**100**	**100**	**100**	**100**	**100%**	**800**				

Note: "**" indicates that the seed is to be sold by variety name and only as a class of certified seed and unauthorized propagation prohibited; "8" indicates unauthorized propagation prohibited, and "Y" indicates a research fee to the university system.
Source: USDA, NASS, ND Field Office, "*North Dakota 2014 Wheat Varieties*", July 2014 and http://www.nd.gov/seed/field_directory/cwht.asp

Crop Acreage Shifts and Wheat Yields in North Dakota

Over the last 35 years there has been a shift in North Dakota acreage. As shown below, total wheat acres fell by 81% from 1981 to 2015 while corn acres rose by 200% and soybean acres increased by over 2000%. Barley and sunflower acres have also fallen (See Figure G.2). In 2014 the value of wheat, corn and soybeans produced in North Dakota were $2 B, $1 B, and $1.9 B respectively.

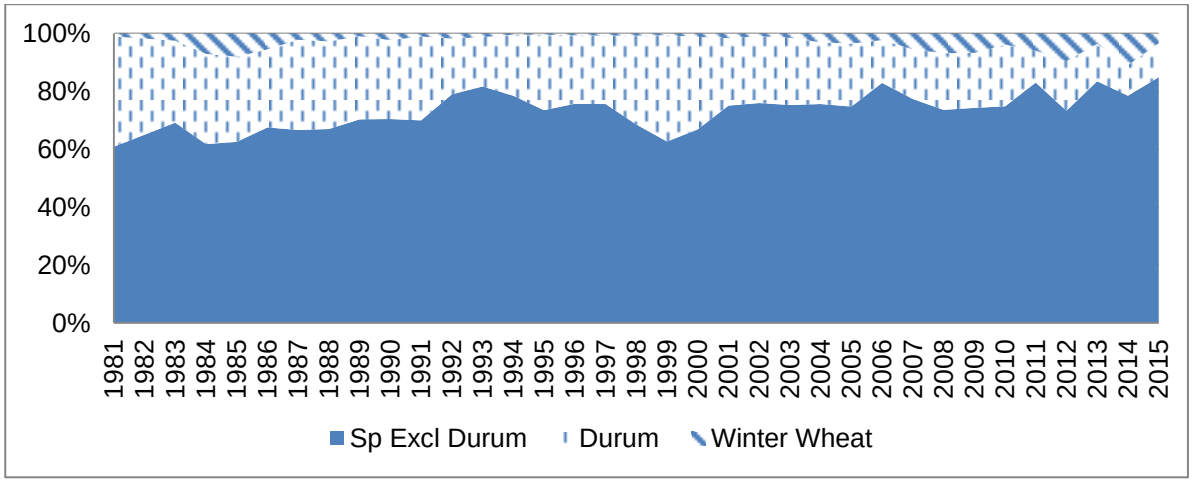
Figure G.2 Shifts in North Dakota Planted Crop Acres.



Source: USDA, NASS

Over time, the makeup of wheat production has changed. While the share of spring wheat (excluding durum) has risen, the share of durum has fallen. The share of total wheat acres planted to winter wheat has increased as indicated in Figure G.3.

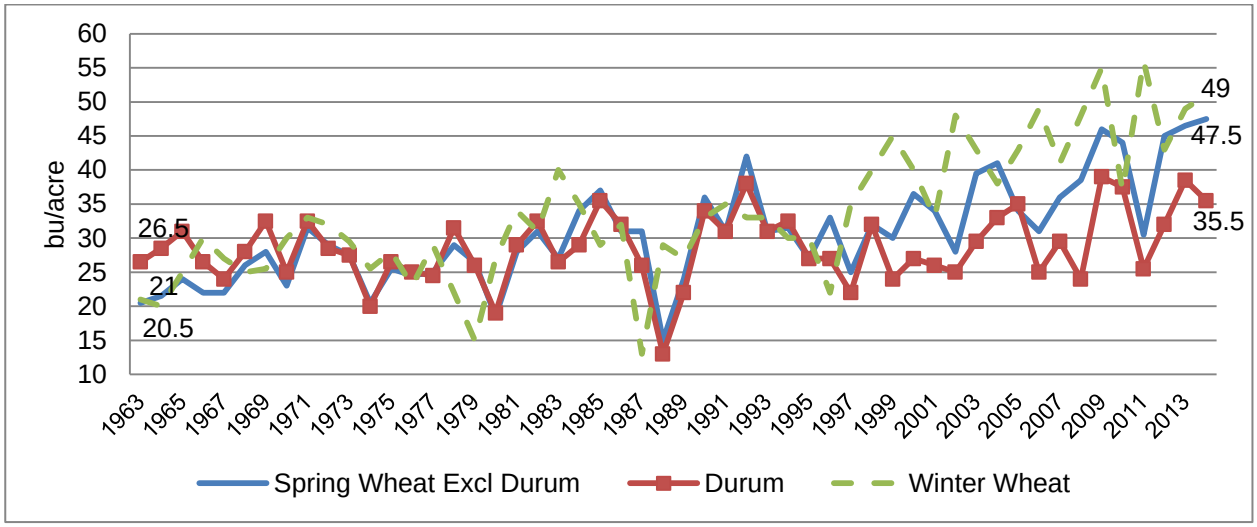
Figure G.3 Share of Wheat Acreage by Class in North Dakota



Source: USDA, NASS

Figure G.4 shows wheat yields in North Dakota from 1963 to 2014. Over this time period, the yield of winter wheat increased at an average annual compound rate of 1.8%. Yield growth for spring wheat excluding durum and durum was 1.7% and 0.6% respectively.

Figure G.4 Trends in North Dakota Wheat Yields, 1963 to 2013



Source: USDA, NASS

Producer Funding of Variety Development in North Dakota

The North Dakota Wheat Commission (NDWC) has a 1.5 cent/bushel ($0.55/tonne) check-off on wheat. In 2013/14, $4.8 M. was collected in checkoff. The NDWC invested $2.1 M in research in areas such as end use quality, breeding/genetics, disease/pest management, marketing/economics and soil science in 2013. In 2013/14, $503,500 was invested in wheat breeding/genetics for hard red spring wheat, hard red winter wheat, durum, and specialty wheat at NDSU.[119]

G.4 Wheat Variety Development in Nebraska

The University of NE-Lincoln (UNL) is the centre of winter wheat development in Nebraska. It collaborates with USDA, state and private researchers in neighbouring states. Funding is received from the state, USDA, private companies, and the Nebraska Wheat Board[120]. The program released one new variety in 2014.[121] There is one primary breeder as well as a USDA geneticist. The overall wheat breeding team is quite large[122]. Husker Genetics, which is owned by the University, increases the seed and after quality assurance or certification by the NE Crop Improvement Association releases or licenses the seed to private companies and certified seed growers[123]. No information on varietal development spending by the U of NE was located.

The UNL collaborates and has agreements with private companies such as BASF (access to Clearfield technology); ConAgra (now Ardent Mills) (support and end-use quality information); Bayer (provides Bayer with non-exclusive access to germplasm); and Limagrain (collaboration on lines and testing).

Bayer Crop Science recently opened a wheat breeding station near Lincoln Nebraska - it's first in the Americas. Bayer hopes to release its first hybrid wheat variety by 2020. The company has also provided $2 M for an endowed chair at the UNL. [124]

[119] North Dakota Wheat Commission, "*Annual Report to Producers 2013-2014*" and http://www.ndwheat.com/research/
[120] As a condition of support the Nebraska Wheat Board requires an annual report on breeding and quality evaluation.
[121] Baenziger P, D Rose, D Santra, M Guttieri, and L Xu, "Improving Wheat Varieties for Nebraska, 2014 State Breeding and Quality Evaluation Report", March 2015
[122] http://cropwatch.unl.edu/wheat/research
[123] http://huskergenetics.unl.edu/
[124] http://www.omaha.com/money/with-new-m-nebraska-facility-and-unl-s-input-bayer/article_dd5185ed-267a-5811-b3f2-db279c10e7e6.html

Use of Certified Winter Wheat Seed in Nebraska

The most recent public survey of winter wheat varieties was conducted in 2012. Shown below in Table G.9 are the survey results for certified seed sales and acreage (shown are the top 10). Also shown are the developer and IP protection. All of these varieties are hard red winter. About two-thirds of the total acreage was planted using U of Nebraska (contributions by USDA) varieties. Varieties developed by other public institutions and the private sector each accounted for about 17% of total acreage.[125] Baenziger et al suggest that in 2014 the Clearfield varieties of Settler CL, Overland, Brawl CL, Robidoux, Byrd, and Infinity CL had the highest combined acreages.[126] Most, but not all, of the varieties shown below are protected by the PVPA. The Clearfield varieties are protected by PVPA 1994, Title V, and usage agreements which require certified seed and prohibit the saving of seed by farmers

The NE Crop Improvement Association with access to certified seed production records estimated that 78% of the winter wheat acres planted in 2014 used certified seed. This amount was 5% more than in 2013 and 16% more than in 2012. Certified seed was used on only 25% of winter wheat acres in 1986. The recent growth in certified seed usage is primarily due to the popularity of the Clearfield wheats which require the purchase of certified seed and prohibit the use of farmer-saved seed.[127]

Table G.9 Share of Top 10 Winter Wheat Varieties by Acreage and Certified Seed Sales (2012)

Rank in Acreage Planted	Rank in Certified Seed Sales	Variety	Share of Winter Wheat Acreage	Share of Certifed Winter Wheat Seed Sales	Developer	US IP	Type
1	3	TAM 111	12.8%	9.4%	TX A & M	PVPA 94	***
2	2	Overland	12.7%	12.4%	NE & USDA	PVPA 94	**
3	7	Pronghorn	9.6%	5.0%	NE & USDA	NP	**
4		Millenium	5.9%		NE & USDA	PVPA 94	**
5		Goodstreak	5.1%		NE & USDA	PVPA 94	**
6	1	Settler CL	4.7%	15.4%	NE & USDA	PVPA 94	***
6		Buckskin	4.7%		NE & USDA	NP	
7	8	Infinity CL	4.3%	4.3%	NE	PVPA 94	*
8		Alliance	3.7%		NE & USDA	PVPA 94	**
9	9	Art	3.6%	3.6%	Syngenta/AgriPro	PVPA 94	
10	5	Winterhawk	3.0%	5.6%	Monsanto/Westbred	PVPA 94	
	4	AP502CL2		6.3%	Syngenta/AgriPro	PVPA 94	***
	6	Wesley		5.1%	NE & USDA	NP	**
	10	Camelot		3.3%	NE	PVPA 94	**
		Total of above	**70.1%**	**70.4%**			

Note: where "*" refers to unauthorized propagation prohibited; "**" refers to be sold by variety name as a class of certified seed and unauthorized propagation prohibited; "***" refers to grower must purchase certified seed and can't save seed and to be sold by variety name only as a class of certified seed; and "NP" refers to not protected and not found in USDA registry of protected plant varieties.

Source: Adapted from Baenziger P, D Rose, D Santra, M Guttieri, and L Xu, "*Improving Wheat Varieties for Nebraska, 2014 State Breeding and Quality Evaluation Report*", March 2015.

[125] TAM 111 was developed by TX A & M but is marketed by Syngenta/AgriPro.

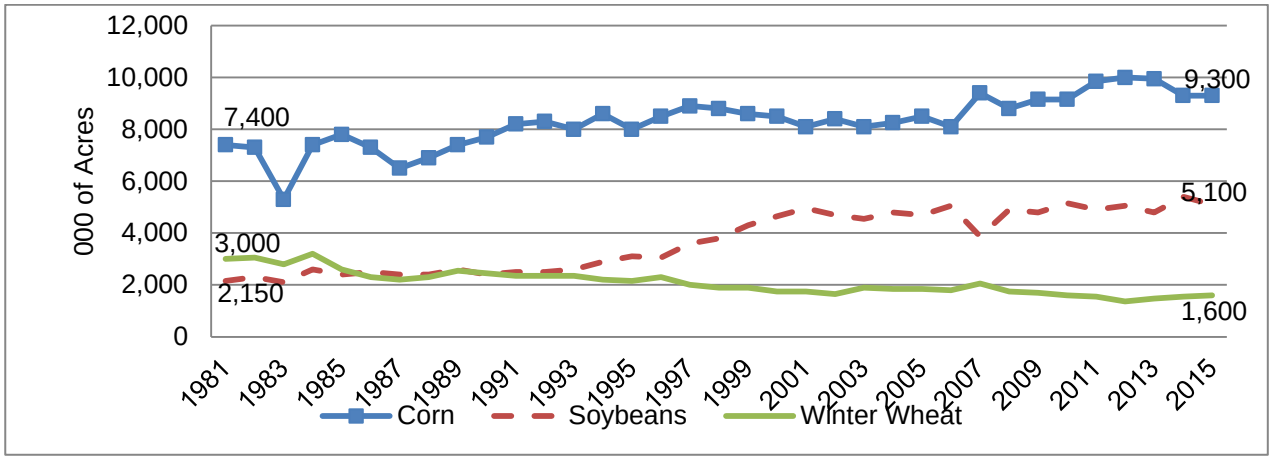
[126] Baenziger P, D Rose, D Santra, M Guttieri, and L Xu, "*Improving Wheat Varieties for Nebraska, 2014 State Breeding and Quality Evaluation Report*", March 2015.

[127] *ibid.*

Nebraska Wheat Yields and Acreage Shifts

The dominant crops in Nebraska are corn, soybeans, and winter wheat (the only type of wheat produced). Since 1981 acres planted to corn and soybeans have trended upwards, while winter wheat acres have fallen (by almost 50%). In 2014, the value of corn, soybeans, and wheat produced was $6 B, $2.8 B, and $412 M.

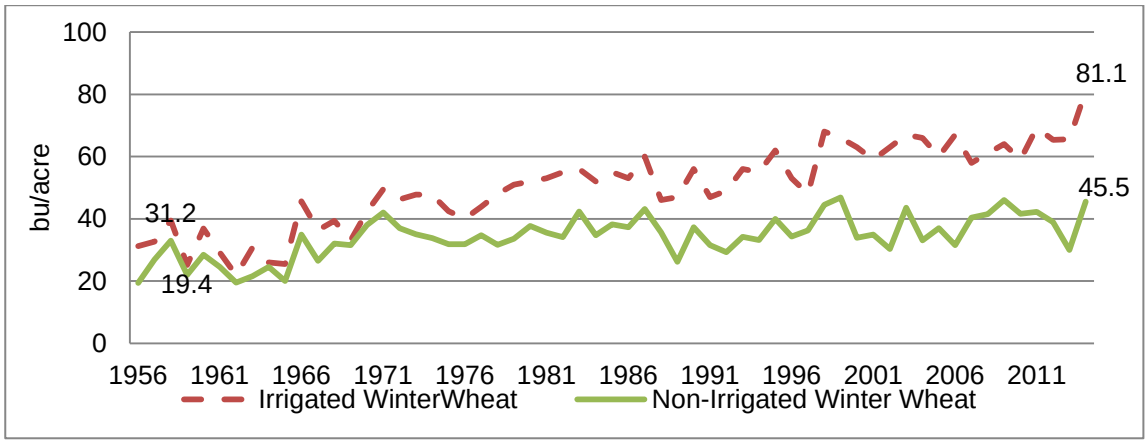
Figure G.5 Nebraska Planted Crop Acreage Shifts, 1981 to 2105



Source: USDA, NASS

About 10% of winter wheat is grown using irrigation in Nebraska. As shown below, the spread between irrigated and non-irrigated yields have increased, with 1.7% annual growth for irrigated and 1.5% for non-irrigated winter wheat.

Figure G.6 Nebraska Winter Wheat Yields, 1956 to 2014



Source: USDA, NASS

Producer Funding of Variety Development in Nebraska

The funds invested by the Nebraska Wheat Board in the U of NE wheat program are from a check-off (0.4% of net value at point of first sale). In 2012/13, $325,000 was provided in support of ten projects by U of NE and USDA. The Nebraska Wheat Board invests about one-third of its check-off dollars on research. [128]

[128] http://www.nebraskawheat.com/about-nwb/ and http://www.nebraskawheat.com/wp-content/uploads/2014/01/FY12-13_Annual-Report.pdf

Relevant Findings and Potential Insights for Variety Development in Canada

This overview provides a number of findings that can be considered as options for wheat and barley variety development. These include:

1. Large classes of wheat attract more interest from the private sector. Durum (small acreage crop) breeding is dominated by the public sector (NDSU). Universities dominate wheat breeding in North Dakota and Nebraska. To date, hard red spring wheat has attracted minimal private sector interest.
2. Winter wheat yields have grown more rapidly than red spring wheat yields and much more rapidly than durum yields.
3. Kansas, North Dakota and Nebraska are facing some of the same issues in the wheat sector as in Western Canada, namely declining acres and lower federal support.
4. Wheat producers in North Dakota and Nebraska have formed partnerships with public institutions (USDA and universities) for wheat variety development, and producers in Kansas have formed partnerships with the private sector.
5. Wheat commissions in Kansas, North Dakota and Nebraska are funded by check-offs, with some of the funds used for variety development. The commissions in North Dakota and Nebraska do not capture value from their investments other than producer access to new and improved varieties.
6. Public institutions (universities and USDA) in North Dakota and Nebraska have separate partnerships with the private sector and producers.
7. Universities collaborate with large private sector companies such as Monsanto and Bayer. Reasons for this include declining wheat acres, lower federal funding, and technical change.
8. Universities will collaborate with large private sector companies to gain specific technology (U of NE and BASF's Clearfield technology).
9. Universities and private companies use PVPA 1994 and Title V to capture value from their varieties. Although there are some wheat varieties with patent utilities there are none for these states.
10. The use of certified seed in Nebraska is growing primarily because of the expansion of Clearfield winter wheat varieties. These varieties require the purchase of certified seed and prohibit farmer saved seed.
11. The experience in Kansas indicates that there is a role for P4s in wheat breeding. Partnerships that result in reductions in time to market benefit private and public breeders. Producers gain through faster yield growth.
12. The KWA, a partnership, licenses traits that are of benefit to producers from the private sector (Clearfield). KSU then develops varieties with the trait (in progress). The KWA also manages the release of varieties from KSU inside and outside of Kansas and receives royalties on the sale of certified seed.

G.5 Barley Variety Development in North Dakota

In North Dakota producers are involved in the development of barley varieties through the North Dakota Barley Council, which was established in 1983.

The ND Barley Council has a refundable check-off of $0.92/tonne on barley sold by producers.[129] In fiscal 2014, the check-off net of refunds raised $772,222. Of this $103,931 was allocated to barley research at NDSU and $30,000 to research at the Northern Crops Institute. [130]

Some of the research underway at NDSU is on the development of new two row malting varieties.[131] The Institute of Barley and Malt Science (IBMS) is part of NDSU. It was established in 2006 to "*provide an interdisciplinary approach to the production, processing, and marketing of barley. Reliable, high quality, targeted research and education programs will be the foundation for the IBMS to assist U. S. barley producers and domestic and international malting and brewing industries at meeting their needs*."[132] The IBMS has ten staff, one of which is a barley breeder.[133] Since 1920 NDSU has released 18 six row varieties. It has released six two row varieties since 1984.[134] Besides funding by the North Dakota Barley Council, other funders include ND Agricultural Experiment Station; USDA-ARS US Wheat and Barley Scab Initiative; USDA-NIFA-AFRI Triticeae CAP (T-CAP); and the American Malting Barley Council.[135]

Table G.10 Barley Varieties in North Dakota, 2012

Variety	Type	Typical Use	Percent	Developer	US IP	Type
Tradition	6 row	Malting	47.0%	Busch	PVPA 94	**
Lacey	6 row	Malting	20.2%	U of MN	PVPA 94	**
Stellar-ND	6 row	Malting	1.6%	NDSU	PVPA 94	**
Conlon	2 row	Malting	4.6%	NDSU	PVPA 94	**
Legacy	6 row	Malting	1.9%	Busch	PVPA 94	**
Robust	6 row	Malting	5.8%	U of MN	PVPA 94	**
Celebration	6 row	Malting	4.9%	Busch	PVPA 94	*
Haybet	2 row	Feed	2.1%	MSU & USDA	NP	
Quest	6 row	Malting	0.2%	U of MN	PVPA 94	**
Pinnacle	2 row	Malting	4.1%	NDSU	PVPA 94	**
Innovation	6 row	Malting	0.9%	Busch	PVPA 94	*
Hays	2 row	Feed	0.4%		NP	
Bowman	2 row	Feed	0.2%	NDSU & USDA	NP	
Logan	2 row	Feed	0.2%	NDSU	PVPA 94	**
Other	NA	NA	5.9%			
Seed Acres Total			1,060,000			

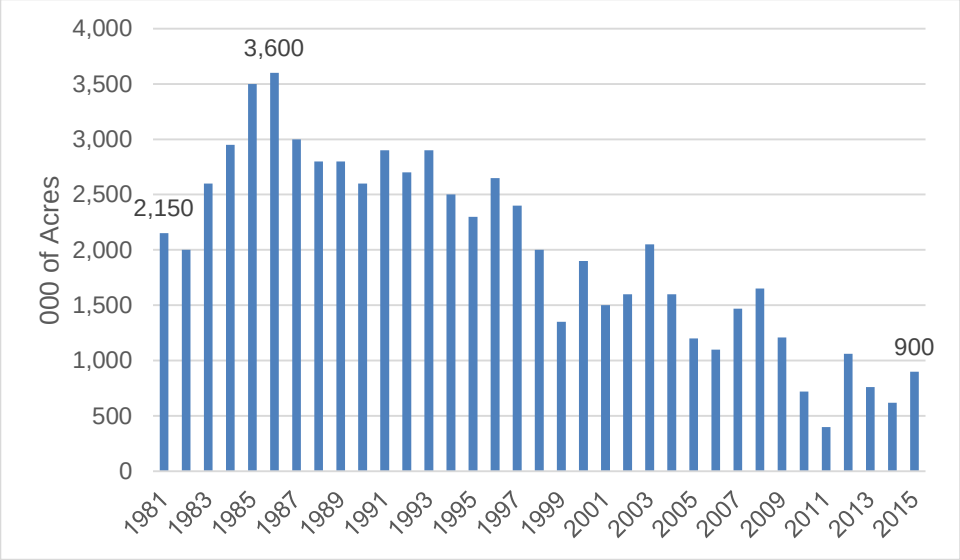
Note: where "*" refers to unauthorized propagation prohibited; "**" refers to be sold by variety name as a class of certified seed and unauthorized propagation prohibited; and "NP" refers to not protected and not found in USDA registry of protected plant varieties.
Source: USDA, NASS, "*North Dakota 2012 Barley Varieties",* 2012 and http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl?

[129] http://www.ndbarley.net/about-us/
[130] Office of the State Auditor, "*North Dakota Barley Council Audit Report*", 2014.
[131] http://www.ndbarley.net
[132] http://www.ndbarley.net
[133] https://www.ag.ndsu.edu/ibms
[134] http://www.ag.ndsu.edu/plantsciences/research
[135] Horsley. R, "*Breeding Malting Barley at North Dakota State University*".

Barley varieties seeded in 2012 are shown above in Table G.10 along with information about acreage share, developer and type of IPR. The variety with the largest acreage was Tradition, a six row malting variety developed by Busch. Varieties developed by Busch accounted for about 55% of total seeded acreage. There were some unprotected varieties. NDSU varieties accounted for about 11%. [136] A survey of companies contracting malting barley in 2014 found that Tradition's share of contracted acres was 50.2%. The next highest shares were Lacey (10.3%), Pinnacle (5%), and CDC Meredith (3.5%).[137]

As shown in the following chart barley acreage has trended downwards since 1986 when it was 3.6 M acres. In 2015, 0.9 M acres of barley were seeded in North Dakota. As with wheat, barley acreage is being pressured by corn and soybeans.

Figure G.7 Seeded Barley Acres in North Dakota, 1981 to 2015



Source: USDA, NASS

G.6 Barley Variety Development in Idaho

In Idaho barley producers invest in varietal research through a $0.66/tonne check-off on barley sales. In fiscal year 2013, the Idaho Barley Commission (IBC) received $456,330 in check-off funds and invested 27% in research. It invested in variety development at USDA/ARS Aberdeen (collaboration with Busch, American Malting Barley Association and the Brewers Association) and Oregon State University. The funds were for the development of winter malting varieties and spring and winter food varieties. The IBC helps support the University of Idaho Tetonia Research Farm and it made a $1 M endowment at the University of Idaho for agronomics and soil science. [138]

The USDA/ARS Aberdeen center was founded in 1922 and currently has an annual budget of $6 M. Barley and potato breeding is conducted there. The National Small Grains Collection is housed at this facility.[139]

In 2012, about 75% of the barley acreage seeded in Idaho were in malting varieties with the remaining 25% in food or feed varieties. Of the varieties shown below, 60% of seeded acres used

[136] USDA, NASS, "*North Dakota 2012 Barley Varieties*", 2012.
[137] American Malting Barley Association, "*Barley Variety Survey – 2014*", January 2015.
[138] Olson K, "*Idaho Barley Commission Legislative Report*", January 2013.
[139] *Ibid.*

barley developed by the private sector. The top malting variety was Conrad, a Busch variety.[140] A survey of companies contracting malting barley in 2014 found that Conrad's share of contracted acres was 20.8%. The next highest shares were Moravian 69 (12.0%), and AC Metcalfe (9%).[141] Malting barley is important to the Idaho economy. There are three malt plants (Anheuser Busch, Great Western Malting, and Integrow) and one private sector barley breeding operation (MillerCoors).[142]

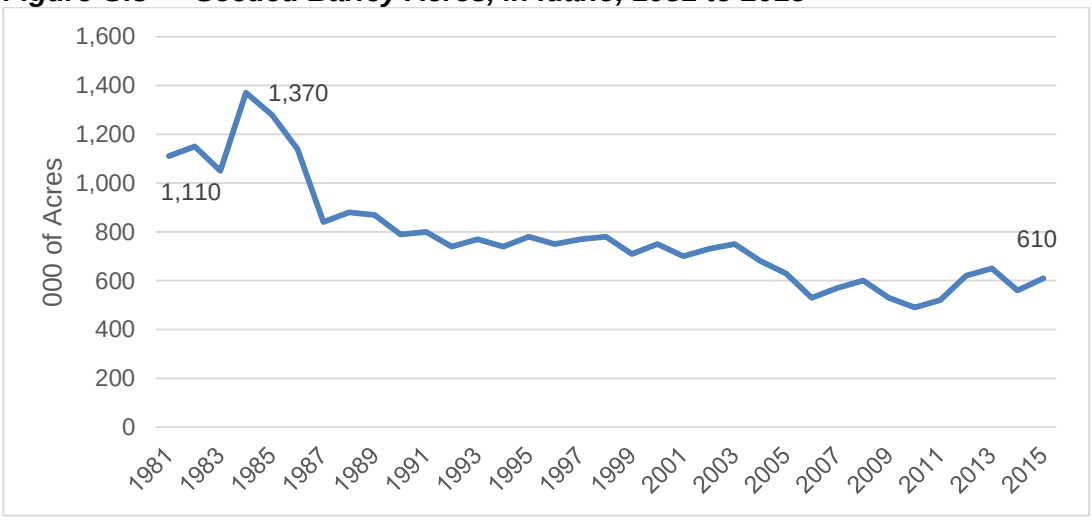
Table G.11 Top Ten Barley Varieties in Idaho, 2012

Varieties	Share (%)	Developer	US IP	Type
Malting				
CONRAD (B5057)	23.5	Busch	PVPA 94	*
AC METCALFE	13.5	AAFC		
MORAVIAN 69 (C69)	11.6	MillerCoors	PVPA 94	**
MERIT 57 (B2657)	8.3	Busch	PVPA 94	*
MERIT (B4947)	4.9	Busch	PVPA 94	**
CDC COPELAND	4.1	U of S		
HARRINGTON	2.9	U of S		
Total Malt	76.2			
FEED/FOOD 2/				
BARONESSE	7.7	WestBred/Monsanto	PVPA 94	*
CHAMPION	4.2	WestBred/Monsanto	PVPA 94	*
CRITON	1.6	U of ID & USDA	NP	
AB 2323	1.3	USDA	NP	
Total Feed	23.8			
Total Acres	610,000			

Note: where "*" refers to unauthorized propagation prohibited; "**" refers to be sold by variety name as a class of certified seed and unauthorized propagation prohibited; and "NP" refers to not protected and not found in USDA registry of protected plant varieties
Source: USDA, NASS, "*Idaho 2012 Barley Varieties*", 2012 and http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl?

In 2015, producers in Idaho seeded 610,000 acres, a 45% drop from the 1.1 M acres in 1981.

Figure G.8 Seeded Barley Acres, in Idaho, 1981 to 2015



Source: USDA, NASS

[140] USDA, NASS, "*Idaho 2012 Barley Varieties*", 2012
[141] American Malting Barley Association, "*Barley Variety Survey – 2014*", January 2015.
[142] http://barley.idaho.gov/profile_partners.html

G.7 Barley Variety Development in Oregon

Oregon barley producers are assessed $1.10/tonne on the sale of barley. The assessment is handled by the Oregon Wheat Commission (OWC).[143] In 2014/15 the OWC intends to invest $38,000 on barley variety development and testing at Oregon State University.[144]

Oregon State University released 10 barley varieties from 1993 to 2014. It currently has one barley breeder. Currently, OSU is developing facultative (can be planted in spring or fall) two row malting varieties, as well as food and forage barley varieties. It is also a participant in USDA-AFRI's Triticeae Coordinated Agricultural Project (TCAP) to develop varieties of wheat and barley that use lower levels of inputs and adapt to changes in climate. The barley breeding program is sponsored by producers, the public sector, industry organizations, and the private sector. Sponsors are shown below.[145]

- Producers:
  - Idaho Barley Commission
  - Oregon Wheat Commission
- Public:
  - Agricultural Research Foundation
  - National Science Foundation
  - United States Department of Agriculture, Agricultural Research Service
  - National Institute for Food and Agriculture
- Industry Associations:
  - American Malting Barley Association
  - Barley Flavor Craft Brew Consortium
- Private Sector:
  - Busch Agricultural Resources,
  - Great Western Malting

Oregon State University is responding to the needs of craft brewers which used 25% of all the malt used by US brewers in 2014. Current malting barley varieties are neutral in flavour.[146] OSU is "testing the hypothesis that barley has positive beer flavor attributes. If there are novel flavors in barley that carry through malting and brewing and into beer, these flavors could provide new opportunities for brewers and expanded horizons for consumers." The project is being funded and assisted by brewers and malsters. [147]

OSU is also working on enhancing Oregon's reputation in craft brewing and distilling by generating data on the agronomic and brewing performance of five barley varieties under three rates of nitrogen fertilization.[148]

In 2015 Oregon producers planted 65,000 acres of barley, a 70% drop from 1981, with peak acreage of 375,000 acres in 1986.

[143] http://arcweb.sos.state.or.us/pages/rules/oars_600/oar_678/678_010.html
[144] http://www.owgl.org/about-us/oregon-wheat-commission/budget-overview/
[145] http://plantbreeding.oregonstate.edu/content/barley-breeding-program and Oregon Wheat, "*Barley Variety Development and Research at Oregon State University*", April 2013.
[146] Brewers Association, "Malting Barley Characteristics for Craft Brewers", 2014.
[147] http://barleyworld.org/breeding-genetics/malting-brewing
[148] *Ibid.*

G.8 Barley Variety Development in Montana

Barley producers in Montana pay a refundable check-off of $0.66/tonne on barley sales.[149] In fiscal 2014, the Montana Wheat and Barley Committee allocated 48% of its budget on research ($2.2 M). The amount invested in barley variety development at Montana State University (MSU) was $60,000. [150]

Montana producers seeded 940,000 acres of barley in 2014 with AC Metcalfe accounting for almost one-third of the acreage (See Table G.11). The top malting varieties were AC Metcalfe, Hockett, Moravian 115 and Contrad. The top forage varieties were Haybet and Lavina while Haxby and Champion were the top feed varieties.[151] Just over two-thirds of the named barley varieties shown in the following table were developed by the public sector with about 30% from MSU. A survey of companies contracting malting barley in 2014 found that AC Metcalfe's share of contracted acres was 16.7%. The next highest shares were Hockett (5.1%) and Moravian 115 (4.6%).[152]

Table G.11 Barley Varieties Seeded in Montana, 2014

Varieties	%	Developer	IP	Type
AC Metcalfe	32.3	AAFC		
Hockett	11.1	MSU	PVPA 94	**
Haxby	9.8	MSU	NP	
Moravian 115	8.9	MillerCoors	Patent	
Haybet	7.9	MSU & USDA	NP	
Conrad	3.2	Busch	PVPA 94	*
Merit 57	2.7	Busch	PVPA 94	*
Tradition	2.3	Busch	PVPA 94	**
Lavina	2.0	MSU	NP	
Harrington	1.9	U of S		
Hays	1.6	Unknown	NP	
Champion	1.6	WestBred/Monsanto		
Conlon	1.4	NDSU	PVPA 94	**
Stockford	1.3	Monsanto	PVPA 94	*
BG 46e	1.3	Monsanto	PVPA 94	
CDC Copeland	1.2	U of S		
Voyager	1.2	Busch	PVPA 94	*
Gallatin	0.9	MSU & USDA	NP	
Hector	0.7	U of A		
Horsford	0.6	F Horsford (1879 or 1880)	NP	
Baronesse	0.5	WestBred/Monsanto	PVPA 94	*
Merit	0.3	Busch	PVPA 94	**
Moravian 37	0.3	MillerCoors	PVPA 94	**
Other & Unknown	5.0			
Seeded Acres	**940,000**			

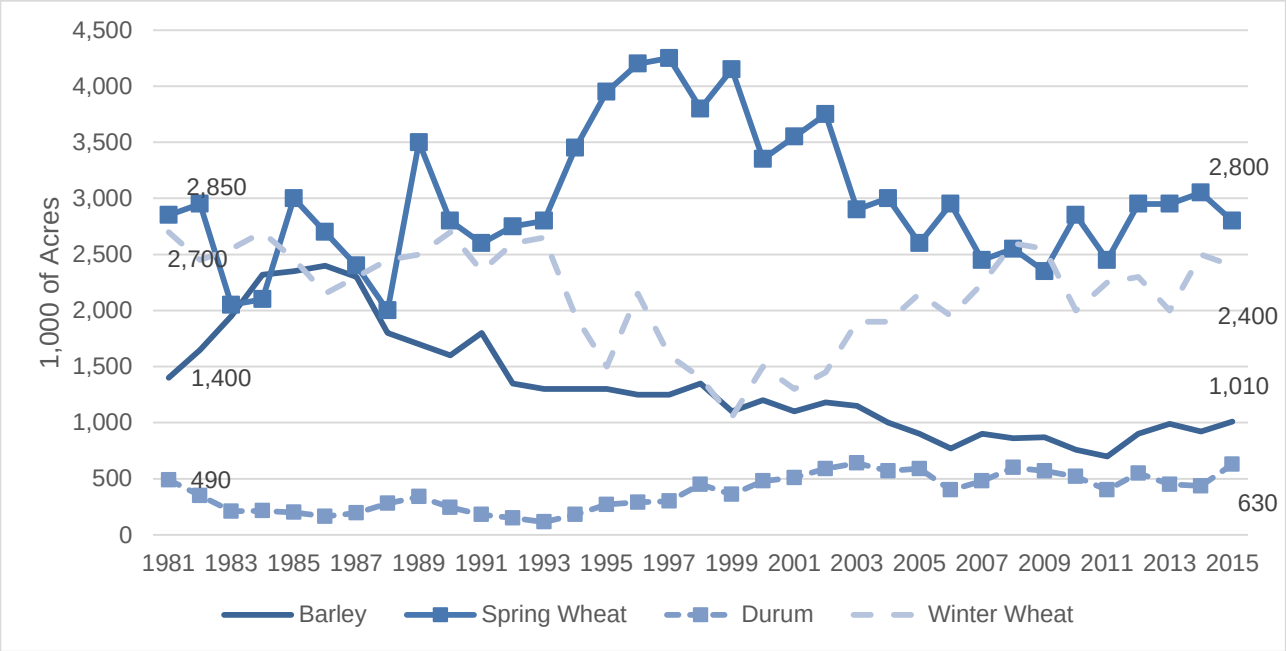
Note: where "*" refers to unauthorized propagation prohibited; "**" refers to be sold by variety name as a class of certified seed and unauthorized propagation prohibited; and "NP" refers to not protected and not found in USDA registry of protected plant varieties

Source: USDA, NASS, "*Montana Barley Varieties 2014*", 2014 and http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl?

[149] http://wbc.agr.mt.gov/wbc/About/
[150] http://wbc.agr.mt.gov/wbc/About/pdf/budget2014.pdf
[151] USDA, NASS, "Montana Barley Varieties 2014", 2014
[152] American Malting Barley Association, "Barley Variety Survey – 2014", January 2015.

Montana's major crops are wheat and barley. Seeded acres of barley, spring wheat, durum, and winter wheat are in Figure G.10. Total wheat acres fell by only 3% from 1981 to 2015 (6.0 M acres in 1981 and 5.8 M acres in 2015). Barley acres were 1.0 M in 2015 compared to 1.4 M acres in 1981, a 28% drop. Corn acres (not shown) are small; with 110,000 acres in 2015. USDA does not report soybean data for Montana. Climatic conditions have not allowed the significant expansion of corn and soybeans seen in other states.

Figure G.10 Montana Seeded Acres in Wheat and Barley, 1981 to 2015



Source: USDA, NASS

Implications for Canada/Key Findings

- US producers face the same challenges as in Canada in terms of declining acreage.
- There is a very significant amount of private sector involvement in the development of malting varieties in the US. This is not the case in Canada. Would the Canadian private sector produce more malting varieties if public breeding efforts were reduced? Would the varieties also meet the needs of producers?
- The growth of craft beer may provide opportunities for producers – small scale IP production of more suitable varieties (for craft beer production).

G.9 Barley Variety Development Centres

The United States has a number of centres engaged in barley variety development, which include:

- Cornell University;
- North Dakota State University;
- Oregon State University;
- University of California - Davis;
- University of Minnesota;
- University of Nebraska;
- University of Wisconsin – Madison;
- University of Virginia;
- Utah State; and
- Washington State University.

Outside of the United States known barley breeding centres include[153]:

- Argentina: INTA Bordenave
- Australia: University of Adelaide, Western Australia Department of Agriculture,
- Brazil: EMBRAPA Trigo (Passo Fundo) and EMBRAPA Cerrados
- Chile: INIA Carrillanca, INIA Quilamapu
- China: Yunnan Academy of Agricultural Sciences; Zhejiang Barley Research Center
- Denmark: Sejet;
- Ecuador: INIAP;
- France: Limagrain, Secobra;
- Germany: University of Weinstephan
- Italy: CRA-GPG, Genomics Research Centre, Fiorenzuola d'Arda;
- Japan: Sapporo breeding program; Yokohama University
- Korea: Barley Research Institute/Suwon, South Korea;
- Mexico: ICARDA/IASA program, INIFAP;
- Peru: Universidad de la Molina, INIA Cuzco
- Sweden: Svalof, Landskrona University;
- Uruguay: INIA La Estanzuela

This suggests that there are a number of breeding centres with which Canadian barley breeders can share information and germplasm, as required for varietal improvement.

[153] Annex A indicates that Canadian barley breeding centres (1) FCDC, (2) CDC, and (3) AAFC in Brandon.

Annex H - Producer Involvement in Variety Development

There are a number of ways producers could be involved in variety development, which include the role of producer organizations, how they are involved, how activities are coordinated, and associated funding of producer involvement. The many aspects of producer involvement are briefly discussed in the section, which can provide some context for the potential options for producer involvement that are considered in the next section of this report.

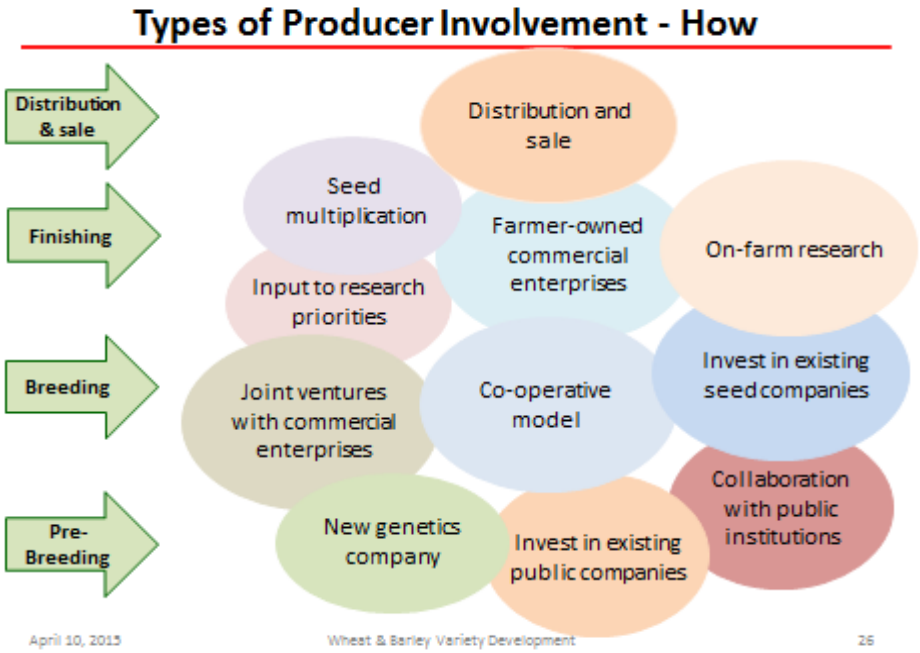
H.1 The Many Ways Producers Could be Involved in Variety Development

The preceding Annexes indicate the many ways producers could be involved in variety development, which include:

- How producers fund variety development, which has been mostly via check-off funding;
- The type of business structure employed by producers, which was mostly as a producer organization using the partnerships model, however, it can include direct ownership;
- Whether producers are involved in some direction setting on breeding and targets;
- Leadership, appropriate governance, identifying gaps and influence on priorities;
- Providing necessary information on marketplace needs;
- Which stage of variety development that producers are most involved in;
- Whether producer involvement is through contract research or through in-house capability;
- How producers capture value based on their funding, whether through improved varieties and/or through a royalty system; and
- The role may need to be crop specific, (e.g., for barley: feed, food, or malt uses);

In western Canada, producer involvement in wheat and barley variety development could occur at each major stage in the variety development process is illustrated in Figure H.1. Involvement could potentially be focused on a number of activities, using collaboration and coordination to having an ownership position in genetics/seed companies.

Figure H.1 Range in Potential Producer Involvement in Variety Development



H.2 Sources of Revenue for Variety Development

There are only a few ways to fund variety development, namely:

- royalties based on farmer purchases of certified seed;
- royalties paid based on the protected varieties that are seeded at planting, including licensing and use agreements that cover conditions of use;
- royalties collected on seed used and marketing of resulting product, such as an EPR system or the extended royalty system used in Uruguay;
- levies assessed on volumes of grain marketed; and
- use of taxpayer funds.

When producers are involved in variety development their revenues sources can, in theory, include all of the above. Taxpayer funds can be a revenue source when producers enter into partnerships with government on variety development initiatives.

Taxpayers are currently the largest source of funds for variety development of wheat and barley in western Canada; however the level of expenditure has been recently declining and divesture is a possibility (see also Table H.1). Producer levies currently raise around $25 million per annum; however, all of these funds are not dedicated to variety development, with an estimated $7.5 million for 2014/15.

Table H.1 Sources of Funding for Wheat and Barley Breeding

Item	Royalties via Certified Seed Sales	Taxpayers	Producer Levies	Royalties via EPR
Current levels	$8 million	$40.5 million	$7.5 million	None
Recent trends	Slow increase	Declining	Increasing	Not implemented
Threats	Divestment, Use of FSS	Divestment	Free riding, Allocation to competing uses	Enforceability, Producer acceptability
Options for increase	Licensing and use agreements, Link with EPR	Effective political lobby	Move to non-refundable levies	Establish an EPR system

With wheat and barley, producers can utilize farmer-saved seed and realize minimal yield drag. This limits the amount of a premium that can be attached to a certified seed sale. As indicated by industry sources, this may not provide a revenue stream large enough to warrant investment in variety development in western Canada. There are options available to capture royalty revenues on farmer saved seed – either when seed is planted or when the harvested crop is sold.

End point royalties or royalty payments based on varieties planted are options that can provide a significant source of revenues for variety development, as witnessed in other jurisdictions that have implemented them.

End Point Royalties[154] and Levies

The *Agricultural Growth Act* creates stronger intellectual property rights and brings Canada into alignment with the provisions of UPOV 91 and creates the foundation for the establishment of contract based EPRs. An EPR can be collected at the first point of sale such as when grain is

[154] In this discussion the term EPR is used; however, the impact of a royalty system based on seed used versus the crop harvested is comparable.

delivered by a farmer to a country elevator or a processor. In such a case, on the surface an EPR appears to be a levy.

The similarity between EPRs and levies is how they are collected; they both use the same collection mechanism.

There is a significant difference between an EPR and a levy. The major difference is that with an EPR, funds automatically flow to the developer of the variety. Supporting information systems that capture acreage planted by seed variety enables EPRs to reward those developing successful varieties. This can be viewed as a demand pull system based on farmer's purchase and use of specific varieties[155]. With a uniform EPR the varieties that have the market share, as chosen by the producers, earn royalties, and any breeder whether public, private, or one that is also a recipient of Commission levies, can compete for these royalties.

There are other differences as well, with check-off levies collected by Commissions being refundable, while EPRs are not. As well, levies collected by Commissions are allocated across a number of areas, which can include agronomy, extension services, advocacy, as well as variety development. A Commission has some discretion on how these producer funds (the levy revenues) are allocated and invested across these competing end uses.

Levies can create pools of funds that can be used by producers for strategic investments, while EPR funds typically flow back to the product developer, hopefully for reinvestment.

Potential Mechanisms to Increase Funding Through an EPR System

Producer involvement in variety development does not need to be limited to a portion of check-off funds collected by provincial wheat and barley Commissions. There are some approaches that can be taken to implement an EPR system, given the legislative authorities. These include:

- Use a federal Act and/or provincial agreements to create a matched National levy/Research Development Corporations (RDC) system;
- Work with governments and industry to develop an Australian style EPR collection mechanism, with different EPR potential for each newly released variety. This approach will take a few years to develop, implement and adopt. After adoption EPRs will tend to increasing at about 0.25% of gross revenue (½ of yield gain) per year;
- Negotiate an agreement between producers and the seed industry to create a uniform EPR system or variety common use fee with revenues that flow back to breeders and ask the federal government for regulations to implement the agreement.

H.3 Ownership Structures and Potential Funding of Variety Development

The different type of ownership structures that are possible and associated revenues to fund variety development are illustrated in Table H.2. Some of these models involve an ownership structure that involves producers, and others have no direct producer involvement, aside from potentially the collective producer voice and/or influence. An example of the latter is a pure public institution, such as AAFC or Agri-Obtentions in France, while a fully private, or publicly-traded, seed company model (such as canola) does not have any direct producer influence.

As illustrated in Table H.2, producers can be involved in models where a levy is the dominant revenue source (producer-private partnership), or a levy is one of a few revenue sources, such as

[155] It can be noted that an EPR system can shift farmers saved seed from being a non-excludable good (in the eyes of the seed company) to an excludable good and thereby capturing the value of the technology embedded in the farmer saved seed.

with the CDC with either wheat or pulses. Levy support allows for funding of producer involvement in variety development in a number of ways, including the formation of Australian-type entities such as GRDC and resulting P4 breeding companies. When there is producer ownership of intellectual property and varieties, royalty payments become another revenue source for continued producer involvement.

Table H.2 Types of Ownership Structures and Revenue Models

Ownership structures	Revenue model		
	Taxpayer	Producer Levy	IPR
Public (AAFC, Agri-Obtentions)	R		
Producer Public (SPG)	R	R	
Public-Private non Profit (Bayer/CDC)	R		
Producer- Private non-profit		R	
Producer Coop (Limagrain)		R	R
P4 – non-profit (CDC wheat)	R	R	
P4 – for profit (AGT)	R	R	R
Private- Producer for profit		R	R
Private-Public for profit	R		R
Private (canola)			R

Note: "R" implies a source of revenue for variety development.

Producers can also be part of models where some taxpayer money is provided (or leveraged) such as a not-for-profit structure that also include government and private seed companies.

A stronger IPR system, such as with EPRs, can include producer involvement, whether in a structure such as Limagrain in France, or Australian Grain Technologies (AGT) in Australia. Limagrain is an example where producers own shares in a breeding cooperative, a structure that results in producers owning tangible assets, such as owning a processing plant.

The above simply illustrates that a number of different types of funding approaches and ownership structures can be considered when developing models for producer involvement in variety development.

H.4 Producer Involvement Shaped by Economic Realities

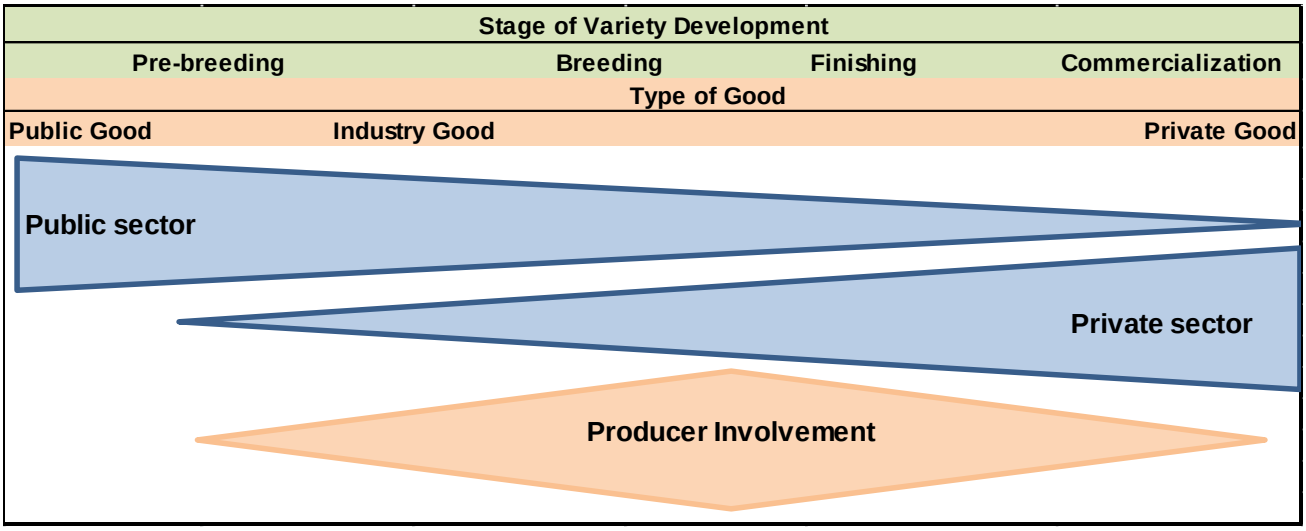
Discussions on the extent and type of potential producer involvement in wheat and barley variety development exist primarily due to certain economic realities:

- That self-replicating attributes of wheat and barley and resulting use of farmer saved seed limits the amount of funds that seed companies can collect, which can be used to fund additional variety development; and
- Certain stages of variety development are essentially collective industry goods, such as genomics and germplasm development in the pre-breeding stage, and private industry has minimal self-interest in generating these knowledge goods based on discovery with long and uncertain pay-back periods, and potential spillover issues. This has been the primary reason why government through their own facilities (such as AAFC) and through supporting breeding programs at universities have provided these industry goods (and could also be public goods). Continuation of this basic research and discovery is potentially at risk with government continuously assessing priorities and associated funding.

Producers are beneficiaries of these industry goods, such as improved varietal performance and accordingly producers have the self-interest to ensure their continuation. This has led to the development of producer partnerships with (1) the public, such as government and universities, and/or (2) private seed companies.

Figure H.2 illustrates how the public, the private sector and producers could be involved in variety development. The public sector has a larger focus on public goods and industry goods – where value cannot necessarily be captured due to non-excludable properties such as knowledge. The private sector has the predominate focus on private goods – goods where value can be captured and the user pays, such as with a new seed variety[156].

Figure H.2 Public, Private and Producer Focus on Variety Development



Potential producer involvement is shown to focus across the stages of variety development, with more involvement ranging from providing industry goods, which benefit producers, through to private goods and release of new varieties.

Practical and Theoretical Arguments for Producer Involvement

One practical argument of why producers should be involved in variety development is to have meaningful influence on the direction of variety development, with such influence typically in proportion to the amount of funding provided by producers, whether through levy based funds or the royalties received based on direct investments in variety development. Such involvement provides producer with significant "voice" as often referred to in academic circles[157].

The other argument is that investments in variety development should increase (based on previously presented comparative analysis) since producers are paying for variety development through either levies and/or royalties captured by breeders, then producers should position themselves through partnerships to influence the direction and focus of variety development.

Another argument is based on economic theory and the types of goods that are generated in the various stages of variety development. With IPR and ability to collect EPRs, the private sector has

[156] While currently private sector involvement is not as large as the public sector, the illustration is designed to show area of focus.

[157] See for example Picciotto, Robert, "*Putting Institutional Economics to Work: From Participation to Governance*", World Bank Discussion Papers 304 (1995).

the incentive to invest in varietal development. However, the private sector has less interest in investing in basic discovery research which provides the platform for future varieties. If governments scale back their involvement in discovery (i.e., pre-breeding), producers lose the benefit of these non-excludable industry goods. Producer partnerships with the public (either government or universities) ensure the knowledge, the basic tools, and the technologies are available for further productivity gains. It is acknowledged that there can be spillovers, with free riding by other countries; however reciprocal arrangements with other jurisdictions or research facilities can be mutually advantageous with these non-excludable industry goods (e.g., knowledge).

H.5 Producer Involvement Through Producer-Public-Private Partnerships

Partnerships are referred to as P3s and P4s, where P4 refers to Producer-Public-Private Partnership and a P3 refers to either a Producer-Private Partnership or a Producer-Public Partnership. Such producer partnerships typically form as a means to finance R&D including variety development. Contributing factors to their development include the need to replace public financing of variety development due to austerity programs, a desire to have a competitive industry, expansions of IPR, privatization of some public sector institutions, and being able to access new technology platforms[158]. Some of these contributing factors were discussed in prior sections (e.g., the sections on Australia, the United Kingdom, and VRIC).

A number of P3 and P4 organizations have been presented in previous Annexes, including organizations and operating structures involving partnerships such as:

- Saskatchewan Pulse Growers, the Crop Development Centre (CDC), government and seed industry which does the seed multiplication, sale and distribution;
- the GRDC and its sponsoring of other producer partnerships such as AGT in Australia, and partnerships that conduct non-excludable research;
- Limagrain's partnerships with providers of non-excludable basic research, and
- Vineland Research and Innovation Centre[159].

Boland indicates that producer partnerships have been effective at linking the R&D requirements of farmers and their financial resources to market outcomes by involving producers in each stage of the innovation process. Boland also indicates the following on producer partnerships:

- *"P4s have developed into a new business model to collectively manage product specific industries in Canada to fill the void created by public austerity and by the failure of the private sector to respond to the needs of the producers";*
- *"Organic organizations developed to create something new in the form of technological innovation."*
- *"Agricultural P3s are a new business model that due to its collaborative structure centres R&D networks by performing the role of gatekeepers by controlling the flow of ideas, people, money and technologies."*

[158] Boland W, "*Public-Private Partnerships for the Management of Agricultural Innovation Systems*", PhD thesis, University of Saskatchewan, 2014 provides an excellent overview of the rationale and growth of P3s and P3s.

[159] Partnerships that readers may be less familiar with are the Centre de development du porc du Quebec (CDPQ), and the Okanagan Plant Improvement Company (PICO). The CDPQ was established in 1992 between Quebec swine producers and the provincial government. It initially received public assets including employees and received public funds. It now generates 75% of its funding from a producer levy and value added services. CDPQ has 50 employees and conducts its own research. PICO was established in 1992 as a partnership between a specialty fruit growers association and an AAFC research centre. The P3 formalized the relationship and gave producers financial responsibility. It is now supported by royalties and Growing Forward funds. PICO has seven employees and contracts out its R&D.

- *"Agricultural P3s integrate science and business by linking R&D expenditures generated by self-organizing producer organizations with the requirements of the market."*
- *"As innovation brokers in agricultural R&D systems, P3s facilitate technological innovation by synchronizing the activities of the public, private, and voluntary sectors."*
- *"Agricultural P3s enable collaboration using voice, trust, and reciprocity";*
- *"These collaborative organizations involve sharing risks, cost and resources as well as long-term commitment (e.g., 10 to 30 years). Such partnerships are initiated to pursue shared objectives, and depend on complementarities between partners*".

Some key learnings regarding agricultural P3s identified by Boland include:

- People are the key influence in formation, not market incentives or public policy;
- Partnerships are dependent on public support because they have long gestation periods and require large initial investments;
- Partnerships are not used to privatize public functions. They are a new form of collaboration; and
- Each agricultural partnership is unique with its structure dependent on partner types and numbers.

Phillips et al[160] provides the following very explicit best practices for P4s:

- "*Successful P4s depend on dedicated and visionary leadership. There is no single source of leaders. While executive leadership is absolutely necessary, it is not enough. Leadership is also needed from producers who engage at the board level to provide the focus and commitment.*
- *While government involvement and leadership is key, it is of a different order. Real and sustained interest by senior officials does not lead to the development of effective P4s; however, it does appear to seal the bonds in P4s. Many producer and private sector partnerships noted that recent changes in federal human resources policies have severed the links between senior officials who are assigned duties with P4s and the P4s. The repeated change in government staff jeopardizes the success of the P4s.*
- *Successful P4s are not simply government by third-party management. These organizations are inherently expensive and high risk ventures that are directed to equally high risk-high activities, such as research, innovation and market development. In brief, all successful P4s mobilized voice. If voice is not needed, then the P4 is not the best model.*
- *Few of Canada's agricultural P4s have significant private commercial involvement. While that type of partner can be valuable, it is neither necessary nor sufficient for a P4 to emerge and operate successfully.*
- *Few of Canada's P4s had any significant formal international partnering. Given the high export-dependence of Canada's agricultural sector, this may be a weakness. Those few that have made limited forays into the global system (e.g. SPG) have had significant success.*
- *P4s are more about projects and development initiatives than program delivery. This new model depends vitally on professional project management skills.*
- *P4s have long gestational periods where they remain dependent on public funds. Generally, the cases suggest it can take more than 15 years to develop independent revenue streams"*.

[160] Phillips P, W Boland, and C Ryan, "*Public-Private-Producer Partnerships (P4s) in Canada*", Report for AAFC, 2013.

H.6 Why Producers Want to be Involved in Variety Development

Producers want to be more actively involved in variety development; why they want to be involved includes:

- producers want wheat and barley to be competitive with other crop kinds and resulting acreage share (this is also a desired outcome);
- public funding is potentially under threat and resulting basic discovery research may diminish; and, accordingly, producers need to have a strategy in place to continue with public involvement in variety development;
- with check-off funds being collected at the provincial level, an approach is required to organize producers and have a more coordinated and effective means to spends these funds on variety development, among other such priorities as agronomic research and market development;
- there are a number of stages in variety development and producers should decide in which areas do they fund variety development – should the majority of resources be directed to variety finishing, or should they be directed towards industry goods, where seed companies are less prone to invest funds;
- there are private sector tools and technologies that should be accessed to benefit producers in variety development; ;
- producers want to understand whether they need to own and operate a seed company, or whether involvement in variety development is through partnerships and leveraging of funds;
- producers also want to understand whether they should capture royalties on investments they fund, or whether the payback is through improved varieties for improved on-farm returns.

H.7 Elements Considered in Developing Potential Producer Involvement Options

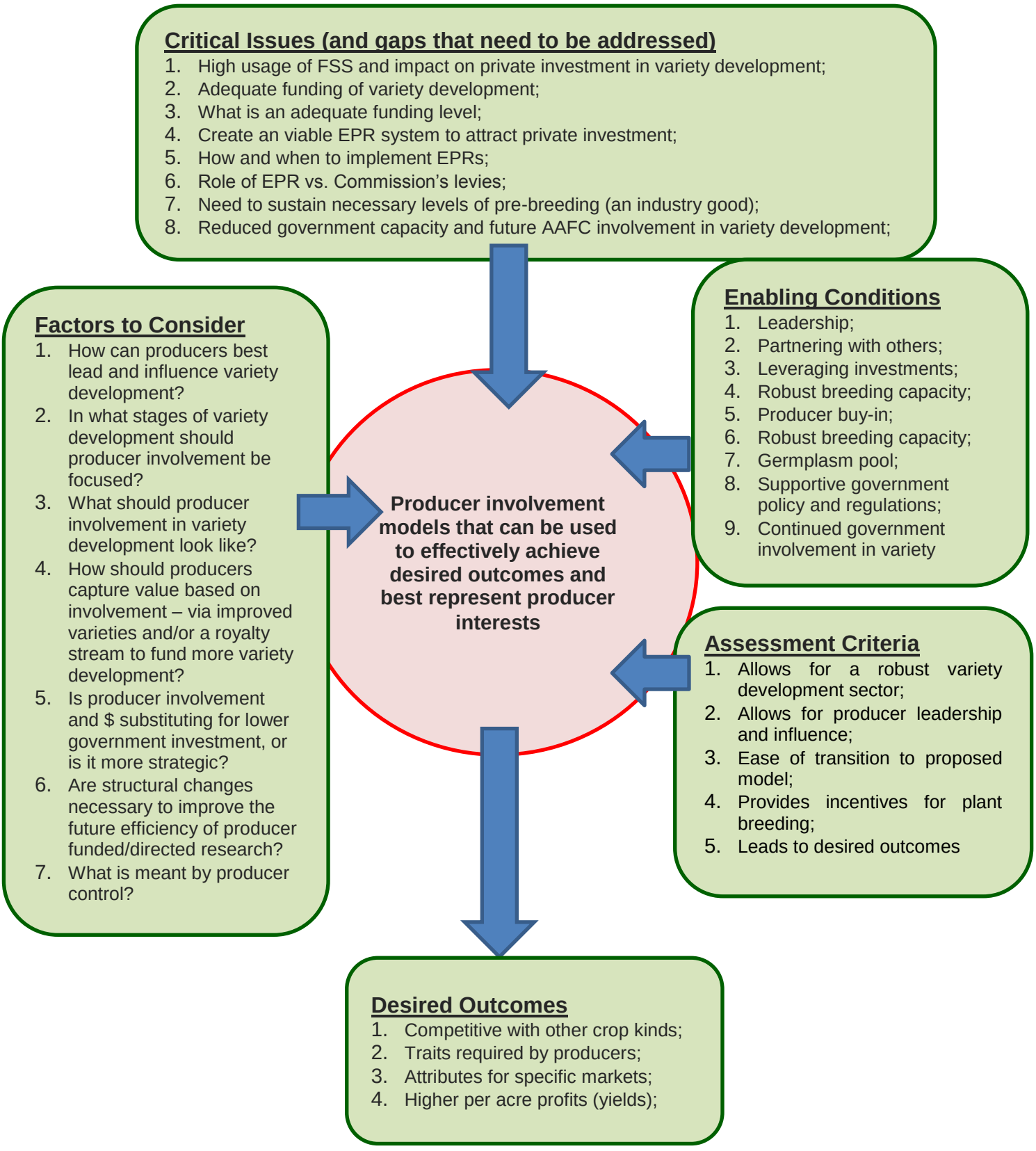
Potential models for producer involvement are outlined in a following section. Figure H.3 illustrates the number of elements being considered in developing the potential models. Our approach to developing potential models first considers the ***desired outcomes***, as noted on the lower portion of Figure H.3. These desired outcomes include:

1. being competitive with other crop kinds;
2. traits desired by producers;
3. product attributes for specific markets; and
4. higher per acre profits, which can be via higher yields.

Models of producer involvement for consideration are guided by how producer involvement can effectively achieve these desired outcomes, as illustrated in the center of Figure H.3. These potential models must ***account for and address the critical issues and current gaps*** previously identified, with these issues highlighted on the top portion of Figure H.3.

A number of ***factors must be considered*** as various potential producer models are developed. An example of such a factor is how can producers most effectively lead and influence variety development. Another factor that needs consideration is whether producer involvement is required in certain stages of variety development for industry sustainability. AAFC has signaled a potential withdrawal from finishing, and the precautionary principal could suggest that there is a reasonable probability that Canada's federal government involvement in discovery research may decrease, such as certain (non-excludable) pre-breeding activities.

Figure H.3 Pathway to Desired Outcomes With Producers Involved in Variety Development



Criteria are used to assess potential options for producer involvement. At the April 10th meeting the Working Group provided input on criteria that could be used to assess potential options for producer involvement in wheat and barley variety development. These criteria are grouped under the headings of: (1) allows for a robust variety development sector; (2) allows for producer leadership and influence, (3) ease of transition to proposed model, (4) provides economic incentives to plant breeders, and (5) leads to desired outcomes[161].

Our assessment will also consider how the potential models could affect conditions that enable the desired outcomes. ***Enabling conditions*** include (1) leadership; (2) partnering with others; (3) leveraging investments; (4) having robust breeding capacity; (5) producer buy-in; (6) a robust breeding capacity: (7) an available germplasm pool; (8) supportive government policy and regulations; and (9) continued government involvement in variety development.

H.8 Elements of Producer Involvement and Potential Approach by Element

There are a number of elements to consider when designing potential models for producer involvements, which are listed in the left hand column of Table H.3. These elements that can characterize potential models and the associated groupings are:

Governance	**Coordination**
1. Board appointment	10. Coordination between producer organizations
2. Advisory	11. Centralized coordinating body
3. Legal entity	12. Role of Commissions
Assets and Infrastructure Support	**Policy/Regulatory**
4. Assets used	13. End Point Royalty
5. Management and human capital	14. EPR and industry goods
6. Acquisition of existing organizations	15. EPR and farmer saved seed
Operations	16. Flow of check-off funds
7. Variety development focus	**Funding of Operations**
8. Partnerships	17. Start-up funding
9. Training of plant breeders/geneticists	18. Funding on-going operations
	19. Royalty stream

With each business model element there are a few approaches that can be considered, and are listed in the accompanying row in Table H.3. A potential business model for consideration by the Working Group can be constructed by selecting an approach for each business model element[162]. **A potential model for producer involvement can be constructed by combining an approach for each element** – it does not need to be from the same column

Governance

The first set of elements is in the area of governance. This includes the ***Board appointment*** and composition. Approaches include whether the Board is appointed by shareholders, by government, or by producers. A model option that requires necessary board governance could have a board that has appointments made by both government and by producers[163].

[161] The criteria under these headings are provided in the next section, which were developed in consultation with the Working Group.
[162] This is provided latter in the following Annex.
[163] With each element only 3 approaches are provided to indicate the range that could be considered. The approaches can be refined, if required.

Table H.3 Producer Involvement - Potential Approaches by Business Model Element

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	By producers
2	Advisory	Only producers	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	Internal staff	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	Finishing	Breeding	Pre-breeding (discovery)
8	Partnerships	With private sector	With universities	With government
9	Training of plant breeders/geneticists	Provide funding to universities	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	Centralized body for decision making and funding	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	Participate in research coordinating body	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	Check-off levies	Government funds	Government provision of existing assets
18	Funding on-going operations	Use check-off levies	A portion of an EPR collected	Royalties and licenses
19	Royalty stream	Licensing of technology	EPR	Certified seed sales

A second model element is the ***advisory body.*** Approaches could include an advisory body composed of only producers, to an advisory body that has producer, public, and private representation as shown in the second row of Table H.3.

The next element is the type of ***legal entity***, with approaches ranging from non-profit and charitable organizations, as currently exists, to either cooperatives (e.g., Limagrain) or for-profit corporations with share capital (e.g., P4s in Australia).

Assets and infrastructure support

Another category of model elements is grouped under the heading of assets and infrastructure support for variety development. The fourth element addresses the ***assets used*** for variety development. Producers can be involved through contracting out research which requires ownership of few physical assets, as is currently the case, and which also occurs with other organizations (e.g., such as USB). Alternatively, producers can have ownership of a seed/genetics company (e.g., such as Limagrain) to achieve the desired ends. As well, producers could have a business entity with in-house research capacity, which is focused on breeding and/or discovery research.

Management and human capital needs and availability is another in this category. This element includes a range of approaches from internal management and employees, to a contractual arrangement with an existing organization such as WGRF, to these services provided by a third party.

Another model element is whether producers ***acquire existing organizations*** involved in variety development. Approaches can include no acquisition, to acquiring a private company, or possibly acquiring some public assets (such as a research station) as occurred with FCDC in Alberta or VRIC in Ontario.

Operations

In the area of business operations, the seventh element is at what ***stage in variety development*** is producer involvement focused. The major focus can be on finishing varieties (such as funding this program at public institutions), on breeding activities (developing new varieties as with the P4's in Australia such as AGT), or on discovery (e.g., germplasm development and genomics as with I/UCRC in Kansas). In what stage of variety development producers are involved is independent of most other model elements; for example, focusing on the industry good of germplasm development can occur through contract research or through direct ownership of a genetics company.

Another element is the level of ***partnerships,*** with the approaches being either P3's (producer and public such as with CDC), or P4s (producer, public, private such as with AAFC/NRC, universities and a seed company).

The ninth business element is whether the business model ensures that there is sufficient human capital available for on-going and future variety development through ***funding training of plant breeders and geneticists*** at universities. Approaches include providing funding to universities for specific deliverables, or funding research Chairs and post-doc fellowships.

Coordination

The tenth element in Table H.3 is the ***level of coordination between producer organizations***. Potential approaches on this element can range from no coordination, to having a centralized body for all decision making and findings with input from each of the provincial organizations (Commissions), to a centralized body for discovery research with provincial Commissions focused on local and small class variety development requirements.

The next element is the ***choice of a centralized coordinating body.*** This could be a newly created organization and possibly one for wheat and one for barley, or use of an existing producer body such as the WGRF, or potentially using Cereals Canada or the national Value Chain Grains Roundtable, with overall value chain representation.

Another element in the area of coordination involves the ***role of Commissions*** in variety development. One approach is for them to forward all check-off funds tagged for variety development to a central body. Another approach could have provincial Commissions forward funds to a central body with the Commissions participating in a research coordinating body. A third approach is to fund and coordinate research within the province. Producer involvement can include a combination of these approaches.

Policy/Regulatory

With legislative and/or regulatory changes, EPRs can be implemented in Canada and another model element is ***design and use of End Point Royalties***. Approaches include no EPR system is used, to a uniform EPR on all wheat and barley marketings (as in France), to a EPRs that are unique to a variety and apply only to new varieties as they are released (e.g., as in Australia).

Another model element involving EPRs, assuming a EPR system is in place, is whether a ***portion of the EPR is dedicated to funding industry good research***, whether at public institutions (e.g., NRC or universities), or whether all of the EPR flows to the developer of a variety.

A model element involving EPRs is whether a ***different EPR applies on farmer-saved seed (FSS)***. Approaches include a discounted EPR on FSS, to no discount on FSS, to an EPR refund on certified seed purchases (assuming a royalty stream is priced into the certified seed price).

Another policy/regulatory model element involves the ***flow of check-off funds***. These funds could remain with the provincial body for their exclusive use. Alternatively these funds can flow to a central body, or potentially a portion flows to a central body and a portion remains with the provincial body for their use in variety development projects that address local issues (as with smaller classes and local agronomic challenges).

Funding of Operations

In the area of funding operations, the seventeenth element is how producers fund their involvement, particularly through ***start-up funding***. One approach for start-up funding is the use of check-off levies and dedicating a certain amount per tonne to variety development. Another approach is to secure a government contribution (or grant) to fund start-up operations, and a third approach is that a government agency transfers assets to the producer organization (as occurred with VRIC).

A related element is ***funding of on-going operations***. Approaches include check-off levies with a specific amount tagged for variety development, or a portion of collected EPRs with the remainder flowing to the owner of a seed variety, or funding through licensing agreements and royalties. With this business element, the on-going funding model could be a combination of these approaches

In addition to funding on-going operations, a further business model element is whether producers ***capture a royalty stream*** based on their involvement in variety development. Approaches include licensing of technology, capturing EPR based on variety ownership, or having a royalty payment on certified seed sales that was developed through producer involvement.

H.9 A Characterization of the Current Model of Producer Involvement

Producers are currently involved in variety development through check-off funds through WGRF programming and more recently through as well provincial commissions. Around $25 million in check-off funds (see Table B.1 in Annex B) are collected each year, with a portion being directed to variety development. This direction is via WGRF funding research projects focused on variety development, such as using the CDC, AAFC, or consortiums/partnerships. More recently, provincial wheat and barley Commissions collect check-off levies which can also be used to fund variety development initiatives.

The current model of producer involvement can be characterized using the approaches by model element in Table H.3; and can be described as:

- most funding is by WGRF, a non-profit organization, through contract research with universities and AAFC (contract of general contributions);
- there is some funding of variety development by provincial Commissions, which is distinct from WGRF funding;
- funding can be allocated to all stages of variety development;
- the current source of funds are check-off levies;
- the role of Commissions in variety development, how such R&D funding is coordinated across these organizations, and whether funds are centralized is being determined.

Annex I – Potential Models for Producer Involvement in Variety Development

Potential models for business development are outlined and then assessed using previously agreed upon criteria in this Annex. These models capture a number of potentially different approaches to how producers could be involved in variety development, and what activities they focus on. The learnings provided by reviewed existing models are used in this development.

Range in Potential Models for Producer Involvement in Variety Development

The business model elements (and associated approaches by model element) in Table H.3 (in Annex H) suggest that a number of choices (or options) are available to producers on how they could be involved in variety development. The range of potential models that can be considered for producer involvement in variety development for wheat and barley include the following:

1. Current Approach with Greater Coordination & Information Sharing;
2. Eight New Provincial Variety Development Organizations;
3. One Non-Profit Producer Body: Wheat and Barley West – With EPR;
4. One Non-Profit Producer Body: Wheat and Barley West – No EPR;
5. One Body Discovers and Deploys Technologies and Traits;
6. Australia North;
7. Modified Australia North - Separate Partnerships for Pre-Breeding and Breeding/Finishing;
8. Farmers Owning Shares in Cereal Breeding Company;
9. Producer Organization Buying an Existing Seed Company;
10. Producer Organization Starting a Seed Company;
11. Technology Value System;
12. Inclusive Model – Producer & AAFC Wheat Breeding Partnership
13. Producer Owned non-Profit Grain Investment Corporation with a focus on Finishing Varieties; and
14. Producer and AAFC owned for profit Canadian Grain Technologies with a focus on Finishing

Each of these potential models is briefly described in following sections, where each model has a table that highlights the approach used for each of the business elements. This description concludes with a rationale of why the particular potential producer involvement model is provided for consideration. At the end of this Annex, the various models are summarized in a table using the model elements described above.

I.1 Assessment Criteria

A set of criteria can be used to assess potential models for producer involvement. At the April 10th meeting the working group provided input on criteria that could be used to assess potential options for producer involvement in wheat and barley variety development. These criteria are grouped and include the following (see also Figure H.3)[164]:

Allows for a Robust Variety Development Sector

- ❑ Provides access to necessary technologies and germplasm;
- ❑ Models must be financially sustainable, secure, and robust;
- ❑ Allows for flexible approaches;
- ❑ Can apply to smaller grain classes and is scalable;
- ❑ Minimize risk of losing the benefit of past investments;
- ❑ Minimize risk of the public sector withdrawal from certain stages of variety development;
- ❑ Promotes knowledge sharing/ limited duplication of effort;
- ❑ Does not hinder investment by others;
- ❑ Mix of private and public breeding;

[164] These criteria were developed in consultation with the Working Group.

Allows for Producer Leadership and Influence

- Producers can provide direction/influence;
- On-going producer engagement and voice;
- Producer control;
- Effective governance;
- Effective partnerships;

Ease of Transition to Proposed Model

- Leverage existing capacity;
- Realistic and easy to implement for all participants;
- Saleable to producers;
- Approach is affordable to producers;
- Meets federal and provincial government ambitions.

Provides Economic Incentives for Plant Breeding

- Capture value/royalties for reinvestment – and potential self-funding over time;
- Attracts investments;
- Competitive seed market;

Leads to Desired Outcomes

- Wheat and barley competitive with other crop kinds;
- Can provide traits desired by producers (e.g., harvestability and disease control);
- Can provide attributes for specific markets (e.g., necessary quality standards);
- Higher per acre profits (yields).

These criteria can be used by the Working Group to assess the potential models suggested for producer involvement. A table is provided at the end of this section for such an assessment.

I.2 Model # 1 – Current Approach with More Coordination & Information Sharing

A potential model is to use the current structures that are in place and have processes in place that result in more coordination and information sharing between the provincial Commissions, the producer organizations, value chain bodies, and the WGRF. This approach is highlighted (**in bold and yellow highlighting**) in Table I.1 and includes features such as:

- All variety development investments are through contract research;
- No new institutions are created;
- Any organization can enter into P3 and P4 partnerships, and can include the private sector, and government and universities in the public sector;
- A portion of check-off funds are used for funding wheat and barley variety development, with such funds remaining with the provincial Commissions – although they can pool funds with other organizations/Commissions for any necessary leveraging;
- Universities are a recipient of funds, based on projects and/or long term partnerships which allows for training of new plant breeders;
- An EPR system is not introduced; however, provincial Commission can receive royalty revenues based on technologies and varieties that are commercialized based on their funding;
- Each of the Commissions participate in wheat or barley research coordinating bodies, which are organized by the WGRF;
- With such coordination across the western provinces, the WGRF (as a central body) would coordinate discovery type research, while the provincial Commissions would ensure that local and applicable smaller class variety development needs are addressed.

A rationale for this potential model for producer involvement in wheat and barley variety development is that new institutions do not need to be created; and through more coordination and

information sharing, investments into variety development will flow to priority areas, with minimal duplication and/or redundancy. As well, producers at a provincial level can direct funds into areas where the potential benefit is seen to the greatest.

Table I.1 Model # 1 - Current Approach With More Coordination & Information Sharing

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	**By government**	**By producers**
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	**non-profit**	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	**Fund via contract research**	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	Internal staff	**Provided by WGRF**	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	**Centralized body for discovery research and provincial body for local/small class requirements**
11	Centralized coordinating body	Newly created organization	**WGRF**	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	**Participate in research coordinating body**	**Fund and coordinate research in own province**
Policy/Regulatory				
13	End Point Royalty	**Not used**	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	**Remains with provincial body**	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	A portion of an EPR collected	Royalties and licenses
19	Royalty stream	**Licensing of technology**	EPR	**Certified seed sales**

I.3 Model # 2 – Eight New Provincial Variety Development Organizations

Having provincially based wheat and barley development organizations fund variety development initiatives can be an alternative to having more coordination and information sharing. As highlighted in Table I.2, this potential model has features that include[165]:

- Each of the provincial wheat and barley organizations separately fund and coordinate variety development via contract research;
- Each of the organizations remains structured as a non-profit corporation and invests in pre-breeding, breeding, and finishing conducted by governments and universities;
- Producers would be nominated by the associated provincial Commission and appointed by the provincial minister of Agriculture for a fixed term on the Board of the organization;
- Funding of universities allows for training of new plant breeders;
- A guaranteed portion of the provincial check-off levy is the major source of start-up funding;
- Ongoing operations are funded by levies and through royalties and licenses;
- The public plant breeding institutions pay a share of royalties to each provincial organization providing the funding;
- Royalties are to be re-invested into wheat and barley variety development;
- There are no EPRs associated with this model.

This model could be viewed as having eight SPG-type operations focused on wheat and barley across the prairies.

A rationale for considering this model is that this provides for provincial autonomy and allows producers to direct funds to local variety development needs and classes of grain grown in their region.

[165] The approach used for a model element is mutually exclusive of the approach used for other elements.

Table I.2 Model # 2 - Eight New Provincial Variety Development Organizations

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	**By government**	**By producers**
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	**non-profit**	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	**Fund via contract research**	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	**None**	Centralized body for decision making and funding	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	Participate in research coordinating body	**Fund and coordinate research in own province**
Policy/Regulatory				
13	End Point Royalty	**Not used**	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	**Remains with provincial body**	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	A portion of an EPR collected	Royalties and licenses
19	Royalty stream	**Licensing of technology**	EPR	**Certified seed sales**

I.4 Model # 3 – One Non-Profit Producer Body: Wheat and Barley West – With EPR

This model is an enhancement of the status quo (or Model # 1 above) and involves a partnership between producers in one central organization. Producers, through their commissions and the WGRF would establish a non-profit organization, Wheat and Barley West (WBW). It would have a Board of Directors appointed by the producer commissions and WGRF. It is a separate organization and would require its own staff[166].

The characteristics and structure of the potential model for producer involvement is summarized in Table I.3 and includes the following highlights:

- Variety development funded by producers via WBW occurs through contracted out research;
- WBW would enter into partnerships with public sector institutions;
- WBW invests in the public sector (AAFC, universities, AARD) in the pre-breeding, breeding, and finishing spaces, as deemed appropriate;
- This model is flexible and could allow WBW to take over the finishing of AAFC varieties if required;
- The private sector would continue to run its own operations in variety development; and would continue to be the sole participant in commercialization;
- Providing funding to universities would ensure that future plant breeders are trained;
- Checkoff funds provide the necessary start-up money, with provincial Commissions forwarding the variety development portion of the check-off levy to the central organization;
- On-going operations are funded by a combination of levy, royalties on licensed technologies and applicable EPR;
- In return for investment by the WBW, public institutions pay a share of royalties to WBW, which are re-invested into wheat and barley variety development.
- There would be another mechanism for value capture besides seed royalties.
- Uniform EPRs are used[167] which applies to all grain marketings, including farmer-saved seed; and
- A portion of the EPR as well as a portion of levy funds is used to fund industry good research.

The outcomes of this model include:

- Greater investment in wheat and barley varietal development (primarily through the EPR mechanism);and
- Over time the greater investment would improve the competitiveness of wheat and barley relative to other crops.

A rationale for this model is that more investment can occur in wheat and barley variety development through the use of an EPR system. This allows private sector seed companies to capture the value of their technologies and varieties. And, at the same time, producers are involved by directing a portion of check-off funds, in a coordinated and centralized manner into variety development projects which are considered important to producers.

[166] An option could be for WGRF or Cereals Canada to administer the new organization.
[167] Collecting a uniform EPR on all wheat and barley marketings would require a change in the Act, while collecting an EPR on new varieties only requires a regulation to the Act.

Table I.3 Model # 3 - One Non-Profit Producer Body: Wheat and Barley West – With EPR

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	**By producers**
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	**non-profit**	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	**Fund via contract research**	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	**Newly created organization**	**WGRF**	**Other existing , such as Cereals Canada**
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	**Uniform on all sales**	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	**Portion of EPR dedicated to industry good research**	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	**No distinction on generation of seed used**	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	**Provided to a central body**	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	**A portion of an EPR collected**	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	**EPR**	Certified seed sales

I.5 Model # 4 – One Non-Profit Producer Body: Wheat and Barley West – No EPR

This model has all of the features of the previous model, with one major difference, which is that EPRs are not part of the variety development system in western Canada.

The features of this potential model for producer involvement are summarized in Table I.4, with the major changes in relation to the prior model being:

- EPRs do not provide a royalty stream for developers of new varieties, which results in a reliance on other mechanisms to capture the value of new varieties, traits, etc., such as licensing and use agreements; and
- Producer funding of variety development through WBW would only be through funds provided via check-off levies.

A rationale for this model is based on the premise that an EPR system may not be supported or developed for wheat and barley in western Canada. The options create a business model that enables producer involvement into variety development in a centralized and coordinated manner.

Table I.4 Model # 4 - One Non-Profit Producer Body: Wheat and Barley West – No EPR

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	**By producers**
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	**non-profit**	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	**Fund via contract research**	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	**Newly created organization**	**WGRF**	**Other existing , such as Cereals Canada**
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	**Not used**	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	**Provided to a central body**	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	A portion of an EPR collected	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	EPR	Certified seed sales

I.6 Model # 5 – One Body Discovers and Deploys Technologies and Traits

In this model the producer check off organizations would undertake additional collaboration to create a new non-profit organization with the specific purpose of discovering and deploying new crop traits and new breeding technologies to be used by Canadian cereal breeders. This model allows producer funded groups to collaborate in order to create the industry goods needed for the sector. This organization could also provide independent research proposal assessment services to member organizations.

Discover and Deploy (DAD) will hire professional staff and expertise to continually proactively scout for new traits and technologies and assess their potential value. Where investment is warranted, DAD will then actively facilitate the development of the technologies through investment, the creation of research consortiums, partnerships etc.

The features of DAD using the model elements for producer involvement are provided in Table I.5, and include:

- DAD has internal capability through its own professional staff;
- DAD is a not for profit organization governed by a Board of Directors appointed by the funding organizations, the provincial Commissions;
- The primary focus of DAD is in the pre-breeding stage of variety development;
- DAD enters in a number of P3 and P4 partnerships;
- DAD start-up funding and on-going funding would be through check-off funds based on a commitment of contributions from check-off organizations.
- Over time check-off contributions could be supplemented by royalty income and license fees as some of the innovations create royalty income; and
- Provincial Commissions are involved in necessary coordination activities through their representation on the Board of Directors.

The rationale for creating a new organization with the explicit purpose of bringing new traits and tools for Canadian would offer several advantages, such as it would:

- facilitate the hiring of specialized staff with the expertise and motivation to proactively identify new traits and process of potential value;
- utilize economies of size in search, procurement, dissemination;
- create the ability to fund projects and operate beyond the 5 year public project cycle;
- increase the ability to collectively partner and collaborate with private firms; and
- develop and house project assessment expertise.

Most of the cereal organizations in western Canada already operate in this space and routinely collaborate on research and industry good projects through clusters consortiums and research project funding, and this new organization would build on this strength for the benefit of the wheat and barley industries.

Table I.5 Model # 5 - One Body Discovers and Deploys Technologies and Traits

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	**By producers**
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	**non-profit**	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	**In house research capacity**	Ownership in a seed/genetics company
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	Finishing	Breeding	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	Provide funding to universities	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	Centralized body for decision making and funding	**Centralized body for discovery research and provincial body for local/small class requirements**
11	Centralized coordinating body	**Newly created organization**	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	**Not used**	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	A portion of an EPR collected	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	EPR	Certified seed sales

I.7 Model # 6 – Australia North

Australia has a much different approach to variety development then in Canada, as noted in section Annex F. Three main features include (1) producer involvement through the GRDC (a partnership between producers and government) and breeding companies established through P4 partnerships that included GRDC, (2) check-off levies and government contributions to the GRDC and its variety development programs, and (3) an EPR system that provides a royalty stream back to plant breeders. In the area of variety development, the primary GRDC focus is on pre-breeding activities and generation of industry goods, with the P4 breeding companies focused on plant breeding, finishing and commercialization. This Australian approach is one business model for consideration in western Canada.

Table I.6 is used to characterize the model we refer to as Australia North. A Grains Variety Development Corporation (GVDC) would be established that exclusively funds and undertakes research that benefits wheat and barley variety development (**see areas highlighted in yellow in Table I.6**).

- The GVDC is a newly created producer-public partnership operating as a non-profit corporation;
- Producers on the GVDC are nominated by provincial Commissions and appointed by the federal government;
- The GVDC would not be involved in agronomics as in Australia;
- The GVDC would contract out research with universities and other research organizations;
- The variety development focus of GVDC would be on discovery research (pre-breeding);
- Sources of funds would be a fixed portion of current check-off levies and co-funding by the federal government (at 50% of the producer levy) as well as licenses fees for technologies provided to plant breeders;
- A specific level of provincial Commission (per tonne) levy would be forwarded to GVDC (some levy would remain with Commissions for other Commission activities such as agronomics, advocacy, policy, etc.); and
- All pre-breeding efforts would be centralized through GVDC.

The GVDC would also enter into P4 partnerships (producer-public-private) for plant breeding. The public portion can be universities, AAFC, and/or provincial governments, and the private portion can range from multi-nationals such as Syngenta to smaller local seed companies. Table I.6 also highlights these P4 characteristics (**areas highlighted in light red**):

- The P4 breeding companies would have assets (breeding infrastructure) and staff provided by former public agencies;
- Plant breeding P4s would focus on the breeding, finishing and commercialization activities.
- Initial funding is through the GVDC until sufficient level of royalties accrue;
- On-going operations are also funded through an EPR that only applies to the release of all new varieties;
- EPR rates are not uniform and can vary by newly released variety; and
- EPR applies equally to use of certified seed, or FSS (when not restricted by a license agreement).

A rationale for considering the Australia North model for producer involvement is that this model does work in Australia, and its success could be replicated in western Canada. Some modifications to the Australia North model are considered in the following option for producer involvement.

Table I.6 Model # 6 – Australia North

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	**By Shareholders**	**By government**	**By producers**
2	Advisory	**Only producers**	**Producers and private**	Producers, public and private
3	Legal entity	**non-profit**	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	**Fund via contract research**	**In house research capacity**	**Ownership in a seed/genetics company**
5	Management and human capital	**Internal staff**	**Provided by WGRF**	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	**Acquire some public assets**
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	With private sector	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	**Newly created organization**	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	Uniform on all sales	**Varies by variety, only on new varieties**
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	**All EPR flows to variety developer**
15	EPR and farmer saved seed	EPR discount on FSS	**No distinction on generation of seed used**	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	**Provided to a central body**	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	**Government funds**	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	**A portion of an EPR collected**	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	**EPR**	Certified seed sales

I.8 Model # 7 – Modified Australia North - Separate Partnerships for Pre-Breeding and Breeding/Finishing

The above model was a replication of the Australia model for western Canada. Another option for consideration of producer involvement includes parts of the Australian model, with (1) a GRDC type institution for wheat and barley (jointly owned by government and producers) which also enters in partnerships with private seed companies and provides funds to universities for upstream research, and (2) producer - private partnerships with seed companies (and producer-private-public partnerships) that focus on breeding, finishing and commercialization.

The model is characterized in Table I.7 and for the pre-breeding stage (**highlighted in yellow**) includes:

- non-profit organization that is a producer – public partnership;
- producer funding is through check-off levies, which is a portion of check-off levies provided to a central producer body, with federal contribution at 50% of producer check-off (with some smoothing using acreage seeded to account for drought years);
- research priorities are coordinated by this central producer body;
- major focus is on discovery research to license non-exclusively to all seed companies;
- research is contracted out with universities and government facilities; and
- licensing of technologies to breeding companies becomes a source of revenues for on-going operations.

For the variety development activities of breeding through to commercialization a partnership of producer-private is created (or producer-private-public), with a focus on taking the germplasm and technologies provided by the above producer-public partnership. There could be two such partnerships, one for wheat and another for barley. The partnership involving producers can be characterized as (see also **light red highlights in Table I.7)**:

- a for-profit organization where producer ownership is through a centralized producer organization, which could be the same organization that is part of the above producer-public partnership;
- the partnership is with a private seed company, which has a focus on breeding through to finishing and commercialization;
- partnerships can also include public institutions;
- the producer contribution is initially through some portion of levy funds, and then through their share of EPR funds;
- a uniform EPR system is used on all grain marketing, allowing for a steady stream of EPR on varieties owned by the partnerships through varieties they own; and
- finishing activities undertaken by government can be transitioned into this partnership.

A rationale for this model is based on making minor adjustments to the Australia North model, with such adjustments being a uniform EPR on all grain sales. While this requires a change in legislation, a uniform EPR provides a source of revenues for investing in variety development by all breeding organizations that is more significant in the start-up years. With an EPR on only newly release varieties, as noted in Australia, it takes many years before a meaningful source of funds is available for investing back into variety development.

Table I.7 Model # 7 – Separate Partnerships for Pre-Breeding and Breeding/Finishing

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	**By Shareholders**	**By government**	**By producers**
2	Advisory	**Only producers**	**Producers and private**	Producers, public and private
3	Legal entity	**non-profit**	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	**Fund via contract research**	**In house research capacity**	**Ownership in a seed/genetics company**
5	Management and human capital	**Internal staff**	**Provided by WGRF**	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	**Acquire some public assets**
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	With private sector	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	**Newly created organization**	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	**Uniform on all sales**	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	**Portion of EPR dedicated to industry good research**	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	**No distinction on generation of seed used**	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	**Provided to a central body**	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	**Government funds**	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	**A portion of an EPR collected**	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	**EPR**	Certified seed sales

I.9 Model # 8 – Farmers Owning Shares in Cereal Breeding Company

In this model producers would invest check–off dollars, through the producer controlled check-off organizations to purchase shares, creating an independent producer owned Breeding Corporation named "Seed Corp". While this model has many common features with model # 6 - Australia North, the direct producer owned corporate structure has an impact on governance and long run security of the breeding activities. This model also shares some features of the ownership and control of Limagrain, the highly successful producer owned multinational seed firm.

Seed Corp would be set up to with the objective of developing and commercializing new cereal varieties for the benefit of producer shareholders. The features of this model are summarized in Table I.8. This model does not rely on an EPR system for success, rather a commitment of check-off levy funds is a requirement for success.

For the initial start-up period, participating (hopefully all) cereal commissions would use check-off resource to purchase shares in Seed Corp. Farmers who contribute to the check-off would be issued a corresponding number of Class A shares in Seed Corp, which would accumulate as investments were made overtime.

Seed Corp would then invest in breeding and commercialization activities on behalf of farmers. This would initially include investment in public breeding programs in return for a share of the varieties created. Seed Corp would then work with public and private firms to commercialize these varieties and earn royalty income.

Seed Corp would be governed by a board of directors elected by Class A shareholders. This might be done from the time of establishment, or it might operate with an appointed board of director during a period of establishment. Class A shares would be converted to non-voting Class B shares (or surrendered[168]) at the time when a producer ceased to be an active farmer, to insure that only active farmers continued to control Seed Corp. While Seed Corp would not directly report to the existing cereal Commissions, it would have strong incentive to work with the Commissions to maximize benefits for the members.

Overtime as royalties increased Seed Corp would generate significant revenue, which would be reinvested in breeding activities. If the Seed Corp generated profits, which did not need to be invested into variety development activities, the Board could decide to have dividend payments to shareholders.

A rationale for this model for producer involvement is that it allows for individual producers to have ownership in a wheat and barley breeding company that focuses on release of varieties with traits of interests to producers.

This model has several appealing features;

- direct producer ownership prevents any particular commission or group being under/over represented in the Seed Corp relative to their investment;
- it creates a single body to coordinate breeding and commercialization activities for cereals;
- it does not interfere with the autonomy of the existing Commissions;
- the direct producer ownership provides ownership security removes any potential for a government action to end producer involvement in breeding; and
- the corporate structure gives Seed Corp greater flexibility in future partnerships and business arrangements.

[168] Limagrain shareholders must be active farmers and must surrender their shares upon retirement.

Table I.8 Model # 8 – Farmers Owning Shares in Cereal Breeding Company (Seed Corp)

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	By producers
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	**In house research capacity**	**Ownership in a seed/genetics company**
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	Pre-breeding (industry good - discovery)
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	**Newly created organization**	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	**Participate in research coordinating body**	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	**Not used**	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	**Provided to a central body**	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	A portion of an EPR collected	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	EPR	**Certified seed sales**

I.10 Model # 9 – Producer Organization Buying an Existing Seed Company

A potential model for producer involvement is highlighted in Table I.9, where individual producers, or existing producer organizations, purchase an existing seed company or the assets of an existing seed company.

Key requirements:

- capital for the initial purchase;
- capital for operations;
- availability of a seed variety development company, or assets, for sale;
- available management/human capital; and
- the ability to identify customer-market requirements.

Attributes of this model include:

- start-up capital initially by shareholders, supplemented by check-off funds. Additional debt capital is likely required;
- a for-profit structure with producer shareholders (commercial producer and seed growers);
- includes breeding, finishing and distribution activities;
- continued public institution involvement in trait and technique development, pre-breeding focus, and public-good traits;
- considerable partnering and licensing agreements with public institutions and the private sector;
- value capture: improved innovation and productivity for all producers; returns to the seed company in royalty streams; ultimate return on investment for shareholders;
- royalty streams could be multiple sources – uniform EPR on all seed sales; certified seed sales; possible licensing of developed technology/innovation to 3rd parties; and
- a centralized body for co-ordination of the variety development processes: market information; funding co-ordination; provincial organizations.

The rationale for this model of producer involvement includes ownership, direction to plant breeding priorities, enhanced competiveness of variety development, and controlled use of producer check-off funding. Risks may include excessive capacity building in variety development, and lack of available funding for existing university and public infrastructure, including human capital development.

Table I.9 Model # 9 - Producer Organization Buying an Existing Seed Company

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	**By Shareholders**	By government	By producers
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	**In house research capacity**	**Ownership in a seed/genetics company**
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	**Acquire a private seed company**	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	**WGRF**	**Other existing , such as Cereals Canada**
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	**Fund and coordinate research in own province**
Policy/Regulatory				
13	End Point Royalty	Not used	**Uniform on all sales**	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	**Portion of EPR dedicated to industry good research**	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	**Refund portion of EPR on certified seed purchases**
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	**60% of funds to central body, 40% remains with provincial body**
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	**A portion of an EPR collected**	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	**EPR**	**Certified seed sales**

I.11 Model # 10 – Producer Organization Starting a Seed Company

A potential model for producer involvement is highlighted in Table I.10, where individual producers, or existing producer organizations, start-up a seed company for wheat and barley variety development. Much of the model element profile is the same as Model # 9; the difference being this is the building of a variety development enterprise versus the purchase of an existing company.

Key requirements:

- capital for the initial start-up;
- capital for operations;
- a "champion" to make it happen;
- time, likelihood of years to fruition;
- available human capital: breeders and knowledgeable management; and
- ability to identify customer-market requirements.

Attributes of this model include:

- start-up capital initially by shareholders, supplemented by check-off funds. Additional debt capital is likely part of the funding model;
- a for-profit structure with producer shareholders (commercial producer and seed growers);
- includes breeding, finishing and distribution activities;
- continued public institutions in trait and technique development, pre-breeding focus, and public-good traits;
- considerable partnering and licensing agreements with public institutions and the private sector;
- value capture: improved innovation and productivity for all producers; returns to the seed company in royalty streams; ultimate return on investment for shareholders;
- royalty streams could be multiple sources – uniform EPR on all seed sales; certified seed sales; possible licensing of developed technology/innovation to 3rd parties; and
- a centralized body for co-ordination of the variety development processes: market information; funding co-ordination; provincial organizations.

Producers starting a seed/genetics company is not new to Canadian agriculture. Examples can be found in most species. In the grain sector, seed growers have been instrumental in starting such companies as Canterra Seeds and FP Genetics. These companies have secured the rights to varieties of seed from different breeders for distribution. Integration into the breeding of varieties is possible and contemplated. For example, Canterra Seeds has recently partnered with Limagrain in integrating its operations to now include a cereals grain breeding operation, Limagrain Cereals Research Canada. This venture has included Limagrain acquiring a minority stake in Canterra.

SeCan is another farmer-based seed distribution enterprise. It is the largest seed distributor in Canada. However, it is an alternatively structured organization, where it has farmer-membership and is not-for-profit. To date, SeCan has returned more than $70 million in royalties and research funding to breeders of cereals, oilseeds, pulses and forage varieties.

The rationale for a producer-started seed company model of producer involvement is if there is a lack of focused infrastructure for variety development and innovation, and if effective partnering with existing public and private organizations cannot be developed. Rationale also includes ownership, direction to plant breeding priorities, enhanced competiveness of variety development, and controlled use of producer check-off funding. Risks may include excessive capacity building in variety development, and lack of available funding for existing university and public infrastructure, including human capital development.

Table I.10 Model # 10 - Producer Organization Starting a Seed Company

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	**By Shareholders**	By government	By producers
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	**In house research capacity**	**Ownership in a seed/genetics company**
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	**Acquire a private seed company**	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	**Breeding**	**Pre-breeding (industry good - discovery)**
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	**Provide funding to universities**	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	**Centralized body for decision making and funding**	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	**WGRF**	**Other existing , such as Cereals Canada**
12	Role of Commissions	**Forward check-off funds to a central body**	**Participate in research coordinating body**	**Fund and coordinate research in own province**
Policy/Regulatory				
13	End Point Royalty	Not used	**Uniform on all sales**	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	**Portion of EPR dedicated to industry good research**	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	**Refund portion of EPR on certified seed purchases**
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	**60% of funds to central body, 40% remains with provincial body**
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	**Use check-off levies**	**A portion of an EPR collected**	**Royalties and licenses**
19	Royalty stream	**Licensing of technology**	**EPR**	**Certified seed sales**

I.12 Model # 11 – Technology Value System

The Technology Value System is an approach to variety development proposed by the CSTA, which relies on an EPR on newly varieties of wheat, oats, and barley. The suggested EPR rate is a uniform $1.50/tonne on newly released varieties, thereby being consistent with UPOV 91.

The royalty is collected at all delivery points (e.g., at elevators, flour mills, feed mills, feed lots, etc.). Producers declare the variety at delivery and any mis-declarations are subject to PBR. Facilities would not be responsible for mis-declarations unless they directed the misrepresentation.

The royalty on legally purchased seed would be refunded.

The EPR would be administered by a central agency (appointed through regulation). The agency would collect and distribute funds, monitor varietal declarations and investigate any PBR breeches. Collected EPR funds are directed to the variety owner or owner of marketing rights. This model has an option of refunding any royalties that may be included in certified seed sales (or producers who legally purchase seed as defined in the PBR Act). The central agency would refund to growers the royalty in relation to the EPR collected.

This proposed model is not focused on how producers could be involved in variety development, rather the focus and overarching rationale is on having breeding companies capturing the value of their new varieties and technologies using an EPR system.

The features of the Technology Value System are highlighted using the producer model elements in Table I.11. The characterization along the producer model elements reinforces a view that this approach is not conducive to producer involvement in variety development.

Table I.11 Model # 11 – Technology Value System

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	By producers
2	Advisory	Only producers	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	Internal staff	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	Finishing	Breeding	Pre-breeding (industry good - discovery)
8	Partnerships	With private sector	With universities	With government
9	Training of plant breeders/geneticists	Provide funding to universities	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	Centralized body for decision making and funding	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	Participate in research coordinating body	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	Uniform on all sales	**Only on new varieties at $1.50/t**
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	**All EPR flows to variety developer**
15	EPR and farmer saved seed	EPR discount on FSS	**No distinction on generation of seed used**	**Refund portion of EPR on certified seed purchases**
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	Check-off levies	Government funds	Government provision of existing assets
18	Funding on-going operations	Use check-off levies	A portion of an EPR collected	Royalties and licenses
19	Royalty stream	Licensing of technology	**EPR**	Certified seed sales

I.13 Model # 12 – Inclusive Model – Producer & AAFC Wheat Breeding Partnership

David Rourke proposed a farmer owned plant breeding model at a forum hosted by Alberta Barley in 2014. The model has producer involvement through a newly established for-profit corporation such as Canada Plant Breeding Ltd (CPB) focused on wheat variety development. It would be a partnership between wheat growers funded through check-offs funds (with individual shares issued to producers) and AAFC.

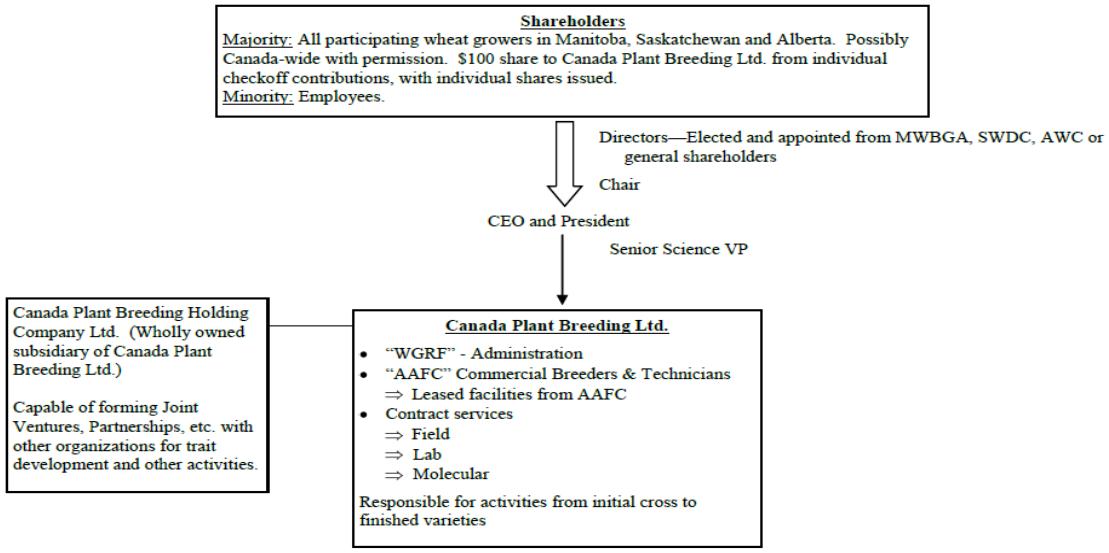
The structure and activities of this model is illustrated in the following charts[169], and the model elements are highlighted in Table I.12, which include:

- The partnership with AAFC would result in AAFC leasing plant breeding assets to CPB, with leased assets including facilities, technicians and plant breeders;
- CPB contract field services, laboratory services, and molecular services;
- CPB focuses on breeding starting with initial crosses (F1 generation)through to finishing;
- AAFC, NRC and other public institutions would continue trait and technique development with outputs such as germplasm and projects (i.e., pre-breeding), and public good traits such as fusarium head blight resistance;
- CPB enters into partnerships with other technology providers to access necessary technologies and traits;
- Commercialization would occurs through existing distribution companies;
- The board of CPB consists of directors elected or appointed from wheat Commissions or general shareholders;
- Key positions in CPB are the CEO and President and a Senior Science VP;
- CPB is administered by WGRF;
- Start-up funding is through check-off levies, and the assets provided by AAFC through the lease arrangement;
- On-going operations are funded through a variety of revenues sources, including memberships, annual dues, WGRF grants, check-off levies provided by Commissions and EPRs (as they come into force);
- CPB would establish a holding company for partnerships, joint ventures, and license agreements. This company could (1) license traits from others (public or private) and supply these to CPB; and (2) do projects with other breeding companies;
- New varieties developed by CPB are licensed to distribution companies and royalties would flow to CPB;
- For AAFC lines finished prior to CPB the royalties would be shared between AAFC and CPB (beginning with at 75:25 split (for AAFC:CPB) until 2017, which is a 50:50 split until 2020, and then a 25:75 split until 2025) to account for lines being commercialized that were being finished prior to the formation of CPB; and
- Value capture by CPB, on behalf of producers, and reinvestment into plant breeding occurs in a number of ways, such as licensing, and EPRs.

A rationale for this model of producer involvement is that producers would have direct ownership in a plant breeding company, which would allow producers to provide direction on plant breeding priorities. This model would leverage existing AAFC assets into a producer controlled model.

[169] These charts were provided by the WGRF.

Proposed Structure for Canadian Farmer-Owned Wheat Breeding Company, "Canada Plant Breeding Ltd."



Proposed Structure and Industry Interactions for Canadian Farmer-Owned Wheat Breeding Company, "Canada Plant Breeding Ltd."

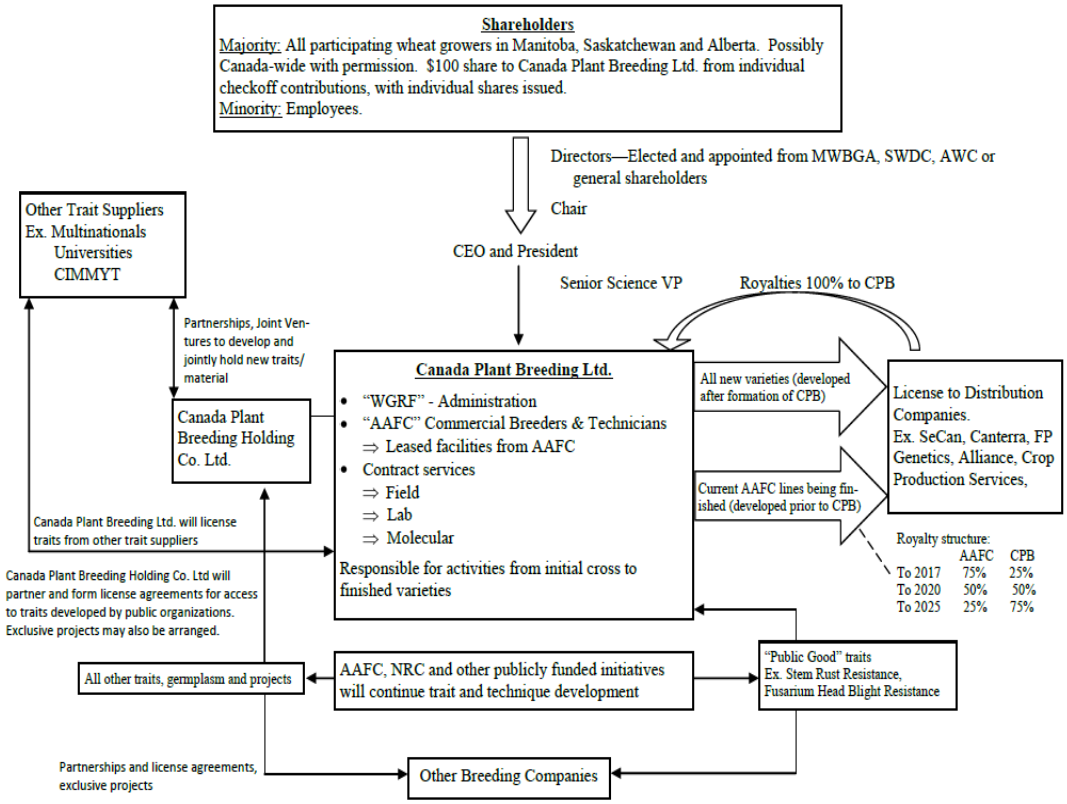


Table I.12 Model # 12 - Inclusive Model – Producer and AAFC Partnership

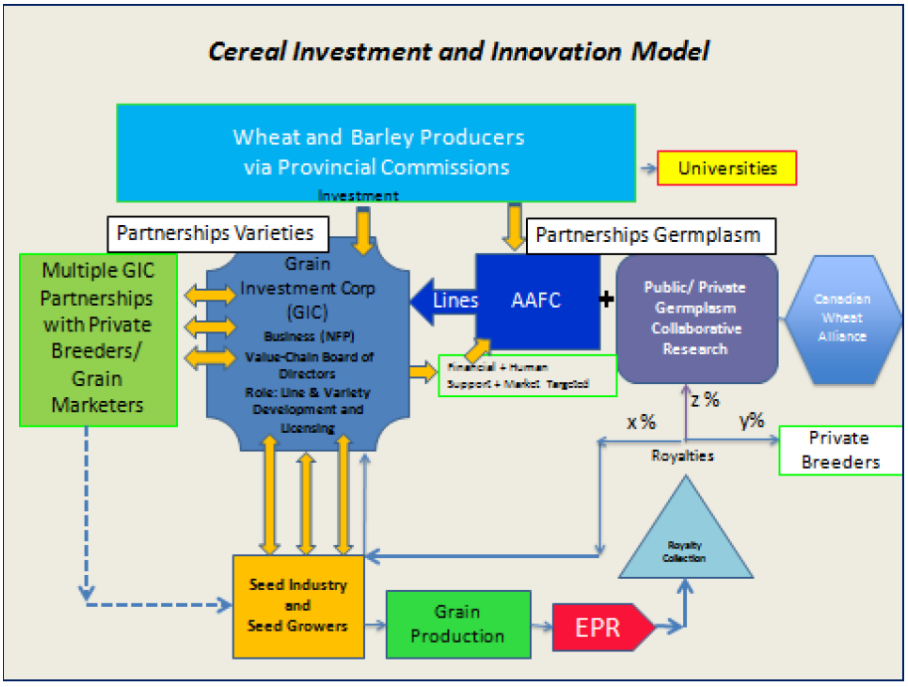
Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	**By Shareholders**	**By government**	By producers
2	Advisory	**Only producers**	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	**In house research capacity**	Ownership in a seed/genetics company
5	Management and human capital	**Internal staff**	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	Acquire a private seed company	**Acquire some public assets - via leasing**
Operations				
7	Variety development focus	**Finishing**	**Breeding**	Pre-breeding (industry good - discovery)
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	Provide funding to universities	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	Centralized body for decision making and funding	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	**WGRF**	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	Participate in research coordinating body	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	Uniform on all sales	**Varies by variety, only on new varieties**
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	**All EPR flows to variety developer**
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	**Government provision of existing assets - via leasing**
18	Funding on-going operations	**Use check-off levies**	**A portion of an EPR collected**	Royalties and licenses
19	Royalty stream	**Licensing of technology**	**EPR**	Certified seed sales

I.14 Model # 13 – Producer Grain Investment Corporation Finishing Varieties

This model was developed as part of a process initiated by Alberta Seed Growers on variety development. An impetus for this model was the announcement by AAFC that it wanted to exit the finishing space. A Producer Partnership Model was developed to "*allow producer involvement through potential partnerships with both public and private sector breeders while at the same time, create an attractive business environment for the private sector.*"[170]

The model is shown in the following chart and its features by model element highlighted in Table I.13.

- A not-for-profit company, Grain Investment Corporation (GIC), would be established which would be owned by producers[171];
- GIC is governed by a board composed of producers and industry experts;
- GIC finishes AAFC's cereal lines, registering varieties and licensing lines in partnership or alone;
- It is not clear whether GIC would have its own in-house capacity, or whether this would be delivered by GIC through contracting out to service providers[172];
- GIC licenses new varieties to existing seed companies for "bulk-up, distribution and sales just as AAFC does currently."
- The GIC can partner with universities and private companies to develop varieties from AAFC lines;
- The GIC also partners/collaborates with private and university cereal breeding entities to exchange germplasm, license other technology, for trait integration, etc.; and
- GIC provides market information to AAFC for germplasm development.

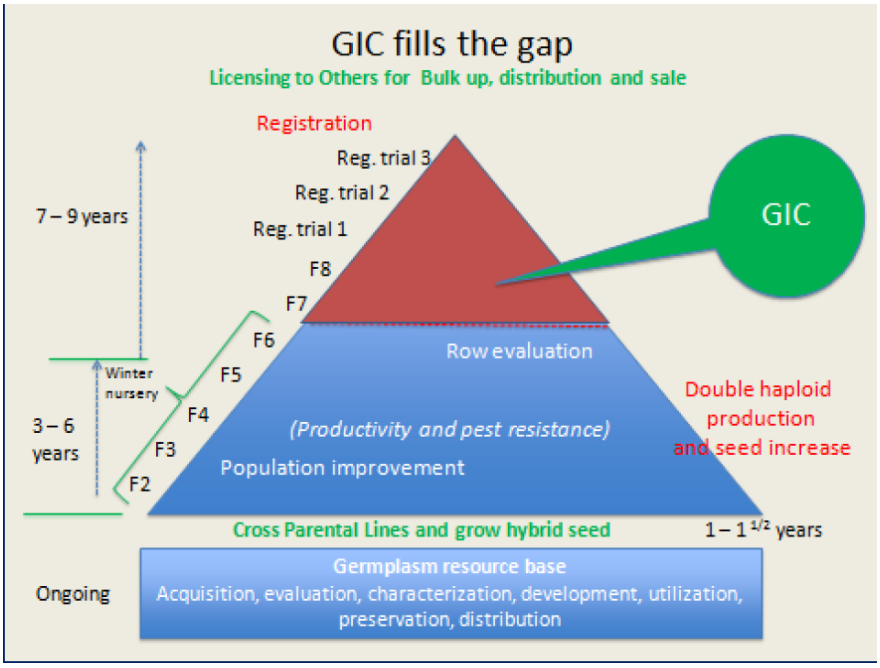


- The Commissions invest in variety development at universities.
- Start-up funding is from the Commissions based on check-off revenues;

[170] This section is from Garvin & Associates, "*Investigation and Development of a New Cereal Breeding Model: Final Report*", 2013.
[171] The slides at the back of the document suggest that others would also be able to invest in the GIC.
[172] There are gaps in the model structure because a business plan for the model was not prepared.

- The model uses an EPR to fund activities and would re-invest a large share of royalty revenues back into variety development;
- Some of the royalties would go to a fund for Public/Private Germplasm Collaborative Research (industry goods);
- Although breeders can chose EPR or seed royalty, varieties licensed and registered by the GIC would be subject to EPR and not royalties on seed;
- EPR from varieties would be shared in accordance with the contribution to finishing and registration;
- The model allows for the co-existence of a private company breeding system and a private/partnership system; and
- AAFC could sell early stage germplasm to private breeders, and the model is based on the assumption that AAFC continues to fund germplasm development at the current level.

The following chart shows the space occupied by the GIC, which is on variety finishing.



The GIC is the **exclusive** finisher of AAFC lines, with AAFC granting such exclusivity because:

- producers have partnered with AAFC in cereal variety development for 20 years,
- cereal producers have invested in the adapted germplasm and in lines under development at AAFC,
- exclusivity is consistent with AAFC's role in creating cereal varieties for the greater industry good and not for the private good, and
- this creates a vehicle for producers to play a strategic role through partnerships with others to finish new varieties.

Table I.13 Model # 13 – Producer Grain Investment Corporation Finishing Varieties

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	By Shareholders	By government	By producers
2	Advisory	Only producers	**Producers and private**	Producers, public and private
3	Legal entity	**non-profit**	cooperative	for profit corporation with share capital
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	Internal staff	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	**None**	Acquire a private seed company	Acquire some public assets
Operations				
7	Variety development focus	**Finishing**	Breeding	Pre-breeding (industry good - discovery)
8	Partnerships	**With private sector**	**With universities**	**With government**
9	Training of plant breeders/geneticists	Provide funding to universities	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	Centralized body for decision making and funding	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	**Forward check-off funds to a central body**	Participate in research coordinating body	**Fund and coordinate research in own province**
Policy/Regulatory				
13	End Point Royalty	Not used	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	**Portion of EPR dedicated to industry good research**	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	**Check-off levies**	Government funds	Government provision of existing assets
18	Funding on-going operations	Use check-off levies	**A portion of an EPR collected**	Royalties and licenses
19	Royalty stream	Licensing of technology	**EPR**	Certified seed sales

I.15 Model # 14 – Producer and AAFC Owned Canadian Grain Technologies

Canadian Grain Technologies (CGT), a for-profit company, would be a partnership between AAFC and producers (individuals and the WGRF) in the variety finishing space. The estimated start-up cost is $30 M ($15 M. from WGRF and $15 M. from individual producers). Significant detail has not been provided on this model, with a brief description[173] provided in Alberta Barley's "Farmer Model Report".

Using the model elements for producer involvement, the producer model can be described as follows (see also highlighted areas in Table I.14):

- CGT owns assets and can be considered a seed company;
- CGT is a for profit corporation with ownership by producers and by AAFC;
- CGT would own some assets that were acquired from AAFC;
- The focus of CGT is on finishing varieties developed by AAFC;
- AAFC would remain involved in the pre-breeding and breeding stages of variety development;
- Sources of revenues are seed sales and royalties on varieties licensed to other seed companies; and
- Profits accruing to WGRF would be re-invested in research benefiting producers.

A rationale for this model is to have producer involved in finishing, given a prior indication that AAFC may be vacating the finishing space in variety development.

[173] Ken Nelson of K.L Nelson and Associates presented this model and is summarized in Alberta Barley, "Farmer Model Report".

Table I.14 Model # 14 – Producers and AAFC Owned Canadian Grain Technologies

Model Elements		Approach #1	Approach #2	Approach #3
Governance				
1	Board appointment	**By Shareholders**	**By government**	**By producers**
2	Advisory	Only producers	Producers and private	Producers, public and private
3	Legal entity	non-profit	cooperative	**for profit corporation with share capital**
Assets and Infrastructure Support				
4	Assets used	Fund via contract research	In house research capacity	Ownership in a seed/genetics company
5	Management and human capital	Internal staff	Provided by WGRF	Provided by third party
6	Acquisition of existing organizations	None	Acquire a private seed company	**Acquire some public assets**
Operations				
7	Variety development focus	**Finishing**	Breeding	Pre-breeding (industry good - discovery)
8	Partnerships	With private sector	With universities	**With government**
9	Training of plant breeders/geneticists	Provide funding to universities	Provide funding for research chairs and post doc fellowships	Not a focus
Coordination				
10	Coordination between producer organizations	None	Centralized body for decision making and funding	Centralized body for discovery research and provincial body for local/small class requirements
11	Centralized coordinating body	Newly created organization	WGRF	Other existing , such as Cereals Canada
12	Role of Commissions	Forward check-off funds to a central body	Participate in research coordinating body	Fund and coordinate research in own province
Policy/Regulatory				
13	End Point Royalty	Not used	Uniform on all sales	Varies by variety, only on new varieties
14	EPR and industry goods	No EPR collected	Portion of EPR dedicated to industry good research	All EPR flows to variety developer
15	EPR and farmer saved seed	EPR discount on FSS	No distinction on generation of seed used	Refund portion of EPR on certified seed purchases
16	Flow of check-off funds	Remains with provincial body	Provided to a central body	60% of funds to central body, 40% remains with provincial body
Funding of Operations				
17	Start-up funding	Check-off levies	Government funds	Government provision of existing assets
18	Funding on-going operations	Use check-off levies	A portion of an EPR collected	Royalties and licenses
19	Royalty stream	Licensing of technology	EPR	**Certified seed sales**

I.16 Summary and Assessment of Potential Business Models for Producer Involvement

A summary of the potential business models outlined above is provided in Table I.15, with the summary based on the approach used for each of the separate model elements.

Table I.15 Summary of Potential Business Models for Producer Involvement (part a)

Model	Option	Governance			Assets and Infrastructure Support			Operations		
		1 Board appointment	2 Advisory	3 Legal entity	4 Assets used	5 Management and human capital	6 Acquisition of existing organizations	7 Variety development focus	8 Partnerships	9 Training of plant breeders/ geneticists
1	**Current +**	Government & producers	Producers	non-profit	Fund contract research	Provided by WGRF	None	All stages	P3 and P4	Provide funds to universities
2	**Eight Bodies**	Government & producers	Producers	non-profit	Fund contract research	Internal staff	None	All stages	P3 and P4	Provide funds to universities
3	**WBW - with EPR**	Producers	Producers	non-profit	Fund contract research	Internal staff	None	All stages	with public	Provide funds to universities
4	**WBW - no EPR**	Producers	Producers	non-profit	Fund contract research	Internal staff	None	All stages	with public	Provide funds to universities
5	**DAD**	Producers	Producers	non-profit	In house capacity	Internal staff	None	All stages	P3 and P4	Not a focus
6	**Australia North**	Government & producers	Producers and Private	non-profit and for profit	Contract research and own seed company	WGRF and Internal staff	P4s acquired some public assets	All stages, with focus by GRDC on pre-breeding	P3 and P4	Provide funds to universities
7	**Australia North modified**	Government & producers	Producers and Private	non-profit and for profit	Contract research and own seed company	WGRF and Internal staff	None	All stages, with focus by GRDC on pre-breeding	P3 and P4	Provide funds to universities
8	**Farmer shares in breeding company**	Shareholders	Producers	for profit with share capital	Own a seed/genetics company	Internal staff	None	Breeding and finishing	P3 and P4	Provide funds to universities
9	**Buy**	Shareholders	Producers	for profit with share capital	Own a seed/genetics company	Internal staff	Acquire some public assets through leasing	All stages	P3 and P4	Not a focus
10	**Build**	Shareholders	Producers	for profit with share capital	Own a seed/genetics company	Internal staff	Acquire a private seed company	All stages	P3 and P4	Not a focus
11	**TVS**									
12	**Inclusive**	Shareholders Government	Producers	for profit with share capital	Use leased assets	Internal staff	Acquire some public assets through leasing	Finishing and breeding	P3 and P4	
13	**GIC**		Producers and private	non-profit			None	Finishing	P3 and P4	
14	**CGT**	Shareholders Government Producers		for profit with share capital	Own a seed/genetics company		Acquire some public assets through leasing	Finishing		

Table I.15 Summary of Potential Business Models for Producer Involvement (part b)

Model #	Option	Coordination			Policy/Regulatory				Funding of Operations		
		10 Coordination between producer organizations	11 Centralized coordinating body	12 Role of Commissions	13 End Point Royalty	14 EPR and industry goods	15 EPR and farmer saved seed	16 Flow of check-off funds	17 Start-up funding	18 Funding on-going operations	19 Royalty stream
1	**Current +**	Centralized body and provincial body for local needs	WGRF	Participate in research coordinating body and fund and coordinate in own province	Not used			Remain with Commissions	Levies	Levies and licenses	Certified seed sales and licensing
2	**Eight Bodies**	None		Fund and coordinate research in own province	Not used			Remain with Commissions	Levies	Levies and licenses	Certified seed sales and licensing
3	**WBW - with EPR**	Centralized body for decision making	New organization, WGRF, and others	Forward funds and participate in research coordinating body	Uniform on all sales	Portion of EPR for pre-breeding	No distinction by seed generation	Provided to a central body	Levies	Levies, part of EPR and licenses	Licensing and EPR
4	**WBW - no EPR**	Centralized body for decision making	New organization, WGRF, and others	Forward funds and participate in research coordinating body	Not used			Provided to a central body	Levies	Levies and licenses	Licensing and certified seed
5	**DAD**	Centralized body for discovery and Commissions for local/small class	New organization	Forward funds and participate in research coordinating body	Not used			Portion provided to central body	Levies	Levies and licenses	Licensing of technology
6	**Australia North**	Centralized body for decision making	New organization	Forward funds and participate in research coordinating body	On new varieties and can vary	All EPR flows to variety developer	No distinction by seed generation	Provided to a central body	Levies, gov't funds, and provision of government assets	Levies, licenses and portion of EPR	Licensing and EPR
7	**Australia North modified**	Centralized body for decision making	New organization	Forward funds and participate in research coordinating body	Uniform on all sales	Portion of EPR for pre-breeding	No distinction by seed generation	Provided to a central body	Levies, gov't funds	Levies, licenses and portion of EPR	Licensing and EPR
8	**Farmer shares in breeding**	Centralized body for decision making and funding	New organization	Participate in research coordinating body	Not used			Portion provided to central body	Levies	Levies, and licenses	Licensing of technology
9	**Buy**	Centralized body for decision making	WGRF and other bodies	Forward some funds, coordination, and some local funding	Uniform on all sales	Portion of EPR for pre-breeding	Refund portion of EPR on certified seed sales	To central body and some remaining/Commissions	Levies	Levies, part of EPR and licenses	Licensing, EPR and certified seed sales
10	**Build**	Centralized body for decision making	WGRF and other bodies	Forward some funds, coordination, and some local funding	Uniform on all sales	Portion of EPR for pre-breeding	Refund portion of EPR on certified seed sales	To central body and some remaining/Commissions	Levies	Levies, part of EPR and licenses	Licensing, EPR and certified seed sales
11	**TVS**		Newly created organization		Uniform $1.50 on new varieties	All EPR flows to developer	Refund for certified seed purchases				EPR
12	**Inclusive**		WGRF		On new varieties and can vary				Levies	Levies, part of EPR and licenses	Licensing and EPR
13	**GIC**		Newly created organization	Send some fund to central body & fund/coordinate at universities		Portion of EPR for pre-breeding			Levies	Part of EPR	EPR
14	**CGT**		Newly created organization								Certified seed sales