Intellectual Property Rights and

Funding Canadian Pulse Breeding for the 21st Century

A Report Prepared for Genome Canada

Katarzyna Bolek[1] and Richard Gray[2]

[1]Katarzena Bolek (PhD) Research Associate, University of Saskatchewan email: kab245@mail.usask.ca

[2] Richard Gray (Professor) University of Saskatchewan email: Richard.Gray@usask.ca

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Executive Summary

Internationally Canada has been, by far, the most successful country when it comes to developing a globally competitive pea and lentil industry. Driven by producer check-off dollars funneled through the Saskatchewan Pulse Growers, the Alberta Pulse Growers, and the Manitoba Pulse Growers and public funding, research investments have led to outstanding success in breeding at the University of Saskatchewan's Crop Development Center. High performance varieties and other complementary research and made pulse production a profitable enterprise for many producers. With widespread producer adoption of pulse crops, these investments have allowed Canada to become an important producer of chickpeas, faba beans and dry beans and the world's largest producer of lentils and dry peas, dominating many export markets. Not surprisingly, economics studies found high rates of return to these past breeding and research investments.

The potential for future growth in pulse production is large. With the increasing demand for plant protein and the need for greenhouse gas mitigation, pulses can play a very important role in crop rotation. The recent mapping of the pea and lentil genome along with the development of new tools has created the scope for more breeding investment. While impressive results for past investments have created billions of dollars in benefits for Canadian producers, the production of pulse crops continues to be challenged by disease and weather-related stresses. For example, in humid weather, the *ascochyta* complex continues to be a major challenge for chickpea, lentil and pea growers, while pea and lentil growers often face yield loss from *aphanomyces* root rot. With the persistence of many disease issues, the scope for pulse crops to become a larger part of prairie cropping systems, and the high rates of return to the investment made to date, several studies have found that increased breeding and research investment would be desirable.

The 2015 Agricultural Growth Act expands plant breeder right's in Canada to be consistent with the UPOV 1991 convention. In other countries, notably the United Kingdom, France and Australia, UPOV91 has enabled the collection of royalties from all producers growing protected varieties. In these countries, the expanded royalty stream has enabled private firms to expand breeding efforts. With the 2015 Agricultural Growth Act in place, Canada can adopt similar systems to enhance royalty income if the industry and policy makers choose to do so.

In the United Kingdom, royalties are paid on certified seed sales and on the use of farm-saved seed (FSS), which are collected by seed cleaners. Farmers are required by law to report farm saved seed use and remit a royalty if it is not collected by the seed cleaner. The FSS royalties are then remitted to the seed companies in proportion to the market share of certified seed. The

royalties are used to support the private firms breeding pulse crops, which are also supported through partnerships with public research institutions. The UK pulse industry investment in pulse breeding has been limited by the small area sown to pulse crops.

In France, most pulse farmers purchase certified seed. Producers are also entitled, by law, to use FSS in return for the payment of an agreed upon royalty to the plant breeder. However, the system has not been well-enforced, resulting in many farmers using farm-saved seed without reporting or remitting a payment to the breeder. France has avoided this problem in wheat by using a uniform end point royalty collected on the sale of wheat called a CVO. In this system, the royalty of €0.7/t is deducted on all wheat sales. Once this deduction has been made, farmers can then apply for a rebate if they can prove they are a small producer, if they did not grow a protected variety, or if they purchased certified seed. Given its simplicity and straight forward enforceability, we consider this a viable mechanism for pulses in Canada.

In Australia, there are no seed royalties but an end point royalty (EPR) is paid whenever a producer sells or uses grain harvested from a protected variety. When seed for a variety is initially purchased, farmers contractually agree to pay an EPR on the sale or use of the harvested material. When the farmer sells the harvest grain, they must, by law, truthfully declare the variety, the grain buyer then deducts the specified EPR for that variety from the purchase price, remits the paperwork and the royalty payment to a central agent who consolidates the royalties and pays each breeder their due. While this system has operated very effectively in Australia, it is slow to generate additional revenue as the breeders must price their varieties to be competitive with any existing royalty free varieties. It is important to note that in addition to EPRs, Australian grain producers also pay a 1% check-off which is matched 0.5% by government, giving the producer-controlled Grain Research and Development Corporation a large role in agricultural research and development.

To evaluate how enhanced royalties could impact pulse producers in Canada, we begin by simulating the royalty streams for Farm-Saved Seed (UK), Uniform EPR (CVO France) and the End Point Royalty (Australia) systems. We begin with a simple case where we assume that all royalties are collected without administrative costs and 90% of the royalty revenue is invested at a 13.5 to 1 benefit cost ratio while the existing checkoffs and public research support are maintained at their current levels. Not surprisingly, we find in this case, all three royalty systems result in over C$2Billion in additional economic benefits with the EPR generating lower return than the other options because of the phase in period.

We then consider cases where less than 90% of the additional royalty income is reinvested. We recognize royalty collection will have some additional administrative costs potentially arising from new laws requiring reporting and compliance. We also note that even if revenue is generated for breeders, it typically will not all be reinvested in breeding. While public enterprises such as the CDC and AAFC may be well equipped to reinvest nearly all the additional royalty revenue they receive, private breeding companies must provide a return to their shareholders. In the case of smaller breeding firms, many will invest up to 30% of their royalty stream into breeding, whereas large companies in an established market typically invest less than 10% of revenue in R&D. As we report in Table 5 below, lower rates of reinvestment substantially reduce the level of investment and the additional returns from a new royalty model. However, we also note that if the reinvestment rate was even lower, it could leave the sector struggling with lower investment. These results suggest any plan to implement a new royalty system must be made with mechanisms to ensure high net rates of reinvestment.

Table 5: Sensitivity to benefit cost ratio and Reinvestment Rate (40-year time frame)

	Assumed long run benefit cost ratio		
	10:1	**20:1**	**40:1**
B: Farm-Saved Seed (UK)	Change in NPV from Status Quo ($Million)		
90% reinvestment rate	$1,269.2	$2,742.8	$5,689.9
60% reinvestment rate	$778.1	$1,760.4	$3,725.2
30% reinvestment rate	$286.9	$778.1	$1,760.4
Breakeven at 6.3% reinvestment rate		$0	
C: Uniform EPR (CVO France)	Change in NPV from Status Quo (Million)		
90% reinvestment rate	$1,276.1	$2,757.6	$5,720.7
60% reinvestment rate	$782.3	$1,769.9	$3,745.3
30% reinvestment rate	$288.4	$782.3	$1,769.9
Breakeven at 6.3% reinvestment rate		$0	
D: Competitive EPR (Australia)	Change in NPV from Status Quo (Million)		
90% reinvestment rate	$833.3	$1,910.1	$4,063.7
60% reinvestment rate	$474.4	$1,192.2	$2,627.9
30% reinvestment rate	$115.4	$474.4	$1,192.2
Breakeven at 10.2% reinvestment rate		$0	

Source: Authors' Calculation as described in the text

For the reasons stated above, the future structure of research and breeding institutions involves several vitally important questions that cannot easily be separated from a royalty discussion. Who will do the research? How will it be funded? What partnerships will exist? Where will the royalty income flow? What are the plans of existing producer organizations including SPG, MPSG, APG, and GFO? What are the plans of existing public institutions including AAFC, CDC, and the private sector? Who will shape viable options for the future of the sector?

In the analysis of the options, it is also very important to understand producer perceptions and attitudes. Collectively, producers have the most at stake economically. Producer voices need to be heard in the political arenas where decisions will be made. Ultimately, producer attitudes will play a key role in compliance, enforceability and collection of royalties.

Keeping in mind that the current Canadian system of funding, governing and conducting pulse research is arguably the most successful in the world, it is vitally important to do no harm. If it is possible to leverage a change in the royalty structure, to make the existing system more robust, this pathway needs to be pursued. On the other hand, if a new royalty structure will do harm to the current system, the net benefit must be clearly understood and articulated.

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0.0 Introduction

Pulses are the dried edible seeds harvested from the pod of plants in the legume family. In Canada, four main pulse crops are being cultivated: dry peas (also referred to as a field peas), lentils, beans and chickpeas. Over the past few decades, pulse production in Canada has grown rapidly making Canada a global leader in pea and lentil production which has provided many benefits for Canadians.

Pulses are also recognized as contributing to healthy diets and sustainable food production. Dietarily, pulse crops are attractive because they are high in protein and fiber, while fat content is low. Environmentally, pulse crops are an important component of zero tillage cropping practices that protect the soil from erosion and enhance soil organic matter. As a nitrogen-fixing crop, pulses also improve the environmental sustainability of annual cropping systems. Through root rhizobia, pulses are able to change atmospheric nitrogen into soil borne nitrogen that can be used as a source of plant nutrients. This ability significantly decreases the quantity of non-renewable energy required to deliver vital nutrients to the crop. Cultivating pulses typically release about one third of the greenhouse gases of other crops, reducing the carbon footprint of the whole crop rotation.

The primary driver of increased Canadian pulse production has been agricultural research and development. Crop breeding has rapidly improved pulse crop genetics, increasing yield potential and many other agronomic traits. Agronomic and other related research has led to the development of zero tillage cropping systems which allow pulses to be profitably grown over millions of acres each year. These developments in turn have created widespread health and environmental benefits for Canadians (DeCicco, 2016; Pulse Canada, 2019).

The success of agricultural research and development (R&D) goes well beyond pulse crops. In the 20th century, agricultural R&D enabled agricultural productivity growth to keep up with the growth in global population from 1.6 billion to 6 billion people (Gray et al., 2017). Future needs are considerable. By 2050, global population is expected to increase by an additional 3 billion people. At the same time, the expansion of the global area of agriculture is limited with dwindling soil, water resources and climate change likely to be challenges for farmers in meeting increasing demand for agriculture products (Hanjra and Qureshi, 2010). Plant breeding has shown to deliver solutions for food security, climate change and contribute to economic growth (Alston et al., 1995). It is crucial that plant breeding advances in Canada so that producers can adopt new varieties which have improved disease resistance, yield potential or other crucial traits (Alston et al., 2009; Godfray et al., 2010; Gray et al., 2017).

Agricultural research is characterized by high internal rates of return. Alston et al. (2000), using a meta-analysis of public agricultural research, found an average internal rate of return to agricultural R&D (Table 12, p.55) to be 81.3 percent per annum and a median of internal rate of return equal to 44.3 percent. Alston et al. also found the mainstream of internal rates of return to agricultural research stated in the literature are between 20 and 60 percent per annum. These rates of return, which are likely noticeably higher than discount rates, suggest both public and private sectors significantly underinvest in agricultural research (Bolek, 2015).

Public expenditures on agricultural research have stagnated in most developed countries. Despite well-documented high rates of return, most governments have been unable to sustain crop research intensity (Gray and Malla, 2007; Alston et al., 2009; Hurley et al., 2016). At the same time, the private sector has targeted its investments to areas where expected research outcomes and property rights offer appropriate incentives (Fuglie et al., 2012). In Canada, the intellectual property rights (IPRs) such as a hybrid technologies and patent protection have helped to create a strong private breeding effort for canola, corn, and soybeans. In order to attract private agricultural research investments, recent public policy aims to strengthen IPRs.

In 2015, the Canadian government passed the Agricultural Growth Act to strengthen the IPRs protection of plant breeders, making Canada compliant with the International Union for the Protection of New Varieties of Plants (UPOV) 1991 convention. The stronger IPRs protection creates new options for increased royalty collection. Working with The Grains Roundtable, Agriculture and AgriFood Canada (AAFC) and the Canadian Food Inspection Agency (CFIA) undertook national consultations to get industry and producer feedback on two new forms of royalty collection: i. End Point Royalties (EPRs) and ii. Farm Saved Seed Royalties (FSSRs) (Groenewegen and Thompson, 2018; Serfas and Gray, 2018). As these consultations continue in 2020, individual producers, producer organizations and industry organizations will provide their input on the royalty collection model they would prefer.

The purpose of this paper is to develop and evaluate these options for pulse royalty collection in Canada. After receiving input from the grain industry, the federal government plans to introduce regulations to support crop royalty collection in Canada. These regulatory changes will impact how crop royalties are collected, how much is collected, and ultimately, future resources for pulse breeding in Canada. This report will help quantify the anticipated costs and benefit and will illustrate how the economic impact of each royalty system will critically depend on the royalty rate, the royalty coverage, the compliance rate, the administrative costs, and the investment rate.

The remainder of our report is organised in sections. Section 1 provides a brief overview of the of pulse production in Canada including its funding mechanisms and development trajectory relative to key competitors. In Section 2, we briefly describe how the Agricultural Growth Act has changed Plant Breeders Rights in Canada to be consistent with the UPOV1991 convention, creating for new options for royalty collection in pulse and others crops. In Section 3, we review the international experience with UPOV 1991 royalty collection systems in Australia, France and the United Kingdom. In Section 4, after describing how these new royalty systems could be adapted and implemented in Canada, we use a model to assess the economic impact these systems would have on Canadian pulse growers over 20, 30, and 40 year time horizons, while paying attention to compliance rates, reinvestment rates, and enforcement costs. In Section 5, we discuss the implications of our analysis for the upcoming dialogue on royalty collection options.

1.0 Plant breeders' rights and Pulse Innovation in the Canada

1.1 The History of Plant IP Protection in Canada

In Canada, the public sector has dominated field-crop breeding for over a century. For many crops including wheat, barley, peas, lentils, flax, and oats, breeding remains dominated by public sector investment with increasing amounts of producer-controlled check-off funding. Breeding programs for crops such as canola and corn are no longer dominated by the public sector. The patented GM traits and hybrid seed provide a strong form of IPR protection (Gray et al., 2001). In the case of patented GM technologies, the patent protection gives its owner exclusive rights to use of the technology. This enables the breeder to collect a royalty every time the technology is used. Patents have created large revenue streams for soybean and canola (Carew, Florkowski and Zhang, 2013; Gray et al., 2017).

Hybrids are a result of the first cross of two genetically different parents. They are a form of technical barrier to saved seed because seed saved from a hybrid variety is more heterogeneous and provides a lower yield compared to the hybrid's parents. Consequently, saving hybrid seed is no longer a rational economic decision, so when a farmer wants to use hybrid seed, he/she must purchase new seed every year. This provides strong IPR protection to the breeder. In Canada, canola and corn are the most broadly cultivated hybrid crops and both have a strong private seed industry (Gray et al., 2017).

In the case of peas, lentils and other pulses, producers have made significant investments in breeding and commercialization of new varieties. Producer funded and controlled organizations have been granted the right under provincial legislation to deduct a check-off or levy on the sale of crops. There are many producer organizations set up to fund agricultural research and many fund crop breeding activities. Established in 1984, The Saskatchewan Pulse Growers (SPG), one of the oldest and one of the largest check-off organizations, has been very successful in developing the pulse sector in Saskatchewan. SPG has a non-refundable check-off, while most others are refundable. This non-refundability eliminates the problem of free-riding, enabling higher check-off rates (Gray et al., 2017).

Previous legislation offering some IPRs protection for plant breeders in Canada include the Seeds Act 1926 and the Plant Breeders Rights Act (the PBR Act) 1998. The PBR Act provided very similar IPR protection to what the Seeds Act offered. The provisions of the Seeds Act 1926 and the PBR Act 1998 did not restrict farmers from using farm saved seed (FSS) nor did they restrict other breeders from using someone else's variety as a parent variety to breed new varieties. The Seed Act 1926 and the PBR Act 1998 gave breeders the right to charge a royalty on pedigree seed sales. Consequently, it became possible to create a well-functioning seed industry, driven primarily by the public sector that provided growers with reasonably priced quality seed of new varieties (Gray et al., 2017). However, private sector investment remains very limited in many crops protected by PBR. Perrin and Fulginiti (2009) showed that if growers have the right to save seed, breeders are only able to capture a very small fraction of value of new variety, which is a serious obstacle for private sector investment in breeding.

The Agricultural Growth Act 2015 introduced new rights for plant breeders in Canada and makes Canada compliant with the International Union for the Protection of New Varieties of Plants (UPOV) 1991 convention. UPOV is an intergovernmental organization operating from Geneva, Switzerland. UPOV was established in Paris in 1961 by the International Convention for the Protection of New Varieties of Plants (the "UPOV Convention"). The UPOV Convention was revised in 1972, 1978, and 1991. UPOV has 74 country members and its mission is "to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society" (UPOV, 2019).

In order to be compliant with the UPOV, member countries must pass laws that create plant breeders' rights consistent with the convention. The UPOV 1961 convention, as well as the Seed Act 1926, recognized that in order for a variety to be registered and protected, it had to be officially verified that the seed variety was new, distinguishable from other varieties, relatively uniform in its essential characteristics, and stable. Owners of registered varieties had the exclusive right to sell seed and breeders had the right to use registered varieties for breeding purposes. All of the UPOV conventions (1961, 1972, 1978 and 1991) allow farmers to save seed for cultivation (Gray et al., 2017). However, the UPOV 91 convention enables the breeders to put contractual conditions on seed saving, restricting these producer rights.

Canada became compliant with the UPOV 78 convention by passing the Plant Breeders' Rights Act in 1998 (PBR 1998). However, the UPOV 78 convention did not restrict the use of harvested material, particularly if it was grown by a producer who had not signed a seed agreement. This weakness in UPOV 78 was recognised and addressed in UPOV 91. UPOV 91 extends the breeders' rights to the sale and use of harvested material from the unauthorized use of the registered varieties. This provision in UPOV 91 and in the Agricultural Growth Act 2015 improves the ability of the breeder to capture value through *closed loop supply chains* or through End Point Royalties (EPRs). EPRs are defined by Kingwell and Watson (1998) as "a levy imposed on the first sale of harvested material derived from varieties protected by plant breeders' rights." (p. 324). This provision enabled the creation of a successful system of EPR collection and subsequently a significant revenue stream for wheat breeders in Australia (Gray et al., 2017).

1.2 The Pulse Sector in Canada

Pulses in Canada are a multi-billion-dollar industry. Canadian production of pulses in 2017 were roughly 7.1 million tonnes, which makes pulses the fifth largest crop in Canada after wheat, canola, corn and barley (Pulse Canada, 2019). As mentioned in the introduction, Canada concentrates production on four kinds of pulses: dry peas, lentils, beans and chickpeas. Internationally, Canada is now the largest producer and the largest exporter of both field pea and lentil (FAOSTATS, 2019).

Although pulse crops are currently very popular, they were practically unknown in Canada in the 1960s. As shown in Figure 1 and 2, since 1990, both pea and lentil production have increased 10-fold in Canada. While peas have followed a linear growth trend since 1990, lentil production has followed an exponential growth path with most of the growth occurring in the past decade.

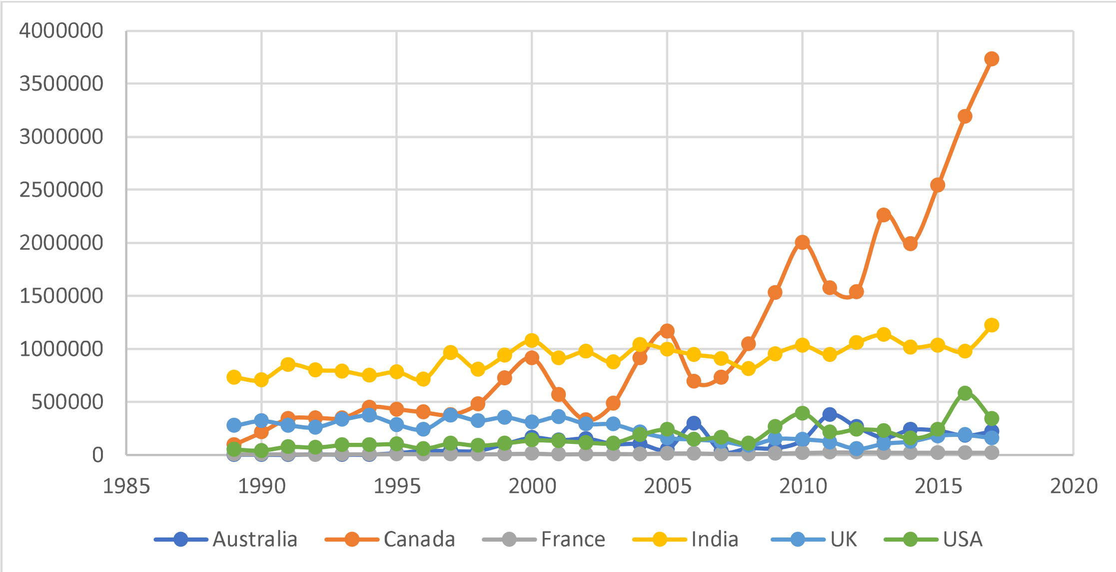

Figure 1 Lentils Production in tonnes in Australia, Canada, France, India, UK and USA, 1989 to 2017
Source: FAOSTATS 2019

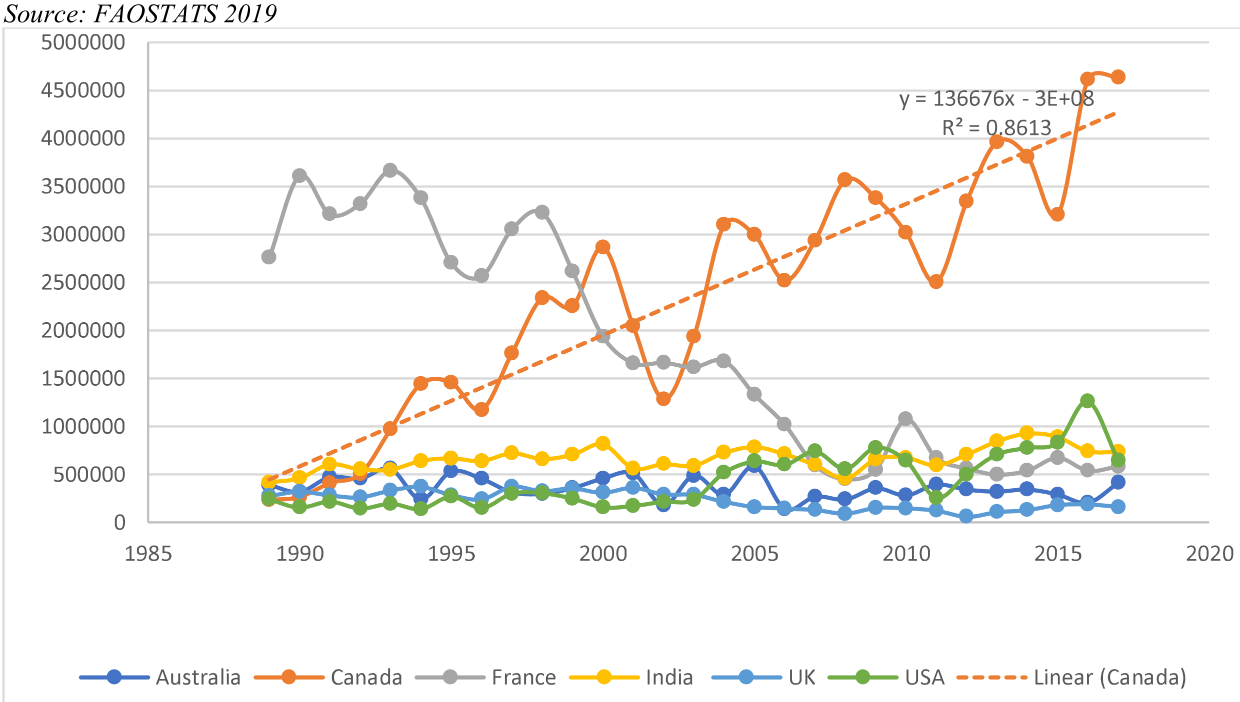

Figure 2 Dry Peas Production in tonnes in Australia, Canada, France, India, UK and USA, 1989 to 2017
Source: FAOSTATS 2019

This increase in production of lentils and dry peas was driven by both area and yield increases. In Figures 3 and 4 we can see significant increases in area harvested for lentils and dry peas. Seeded hectares for lentils and dry peas have increased by 1.9 million hectares and 330 thousand hectares, respectively, in the past 10 years.

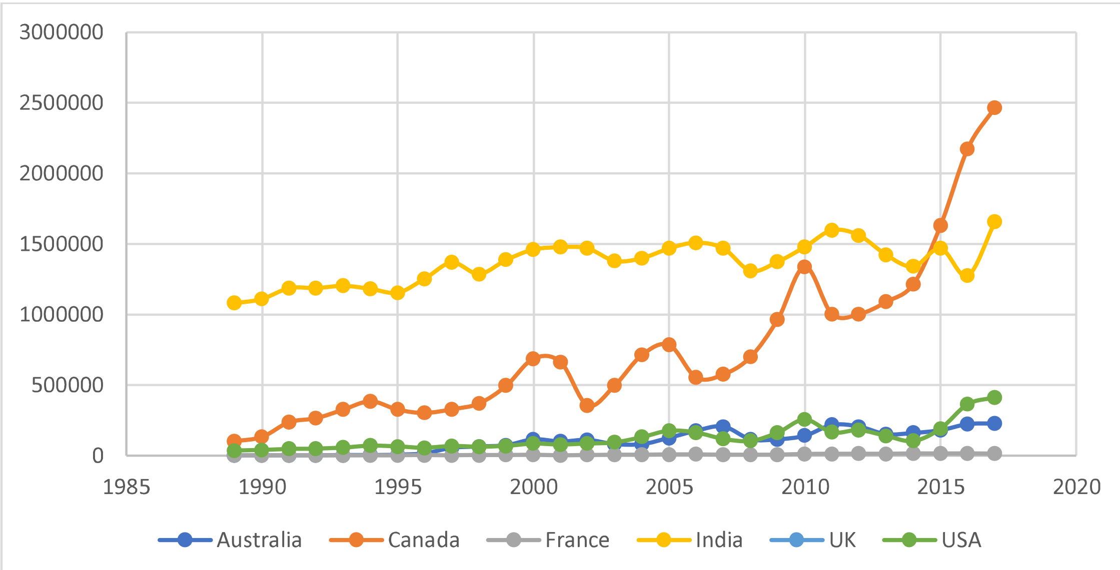

Figure 3 Lentils Area Harvested in ha in Australia, Canada, France, India, UK and USA, 1989 to 2017
Source: FAOSTATS 2019

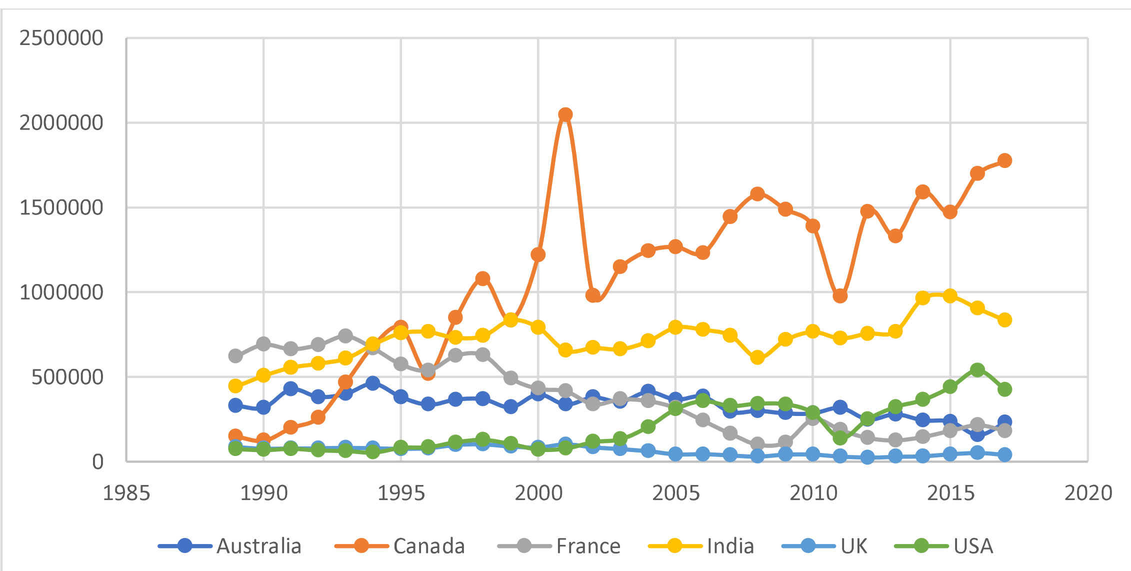

Figure 4 Dry Peas Area Harvested in ha in Australia, Canada, France, India, UK and USA, 1989 to 2017
Source: FAOSTATS 2019

As shown in Figures 5 and 6, yield, although volatile, has trended upward over the long run. The year-to-year volatility of yield is caused by weather. The upward sloping yield trend for pea owns to the development and commercialization of new varieties as well as the agronomic improvement (Carew, Florkowski and Zhang, 2013). This upward trend in seeded hectares and realized yield provides significant value to the Canadian economy.

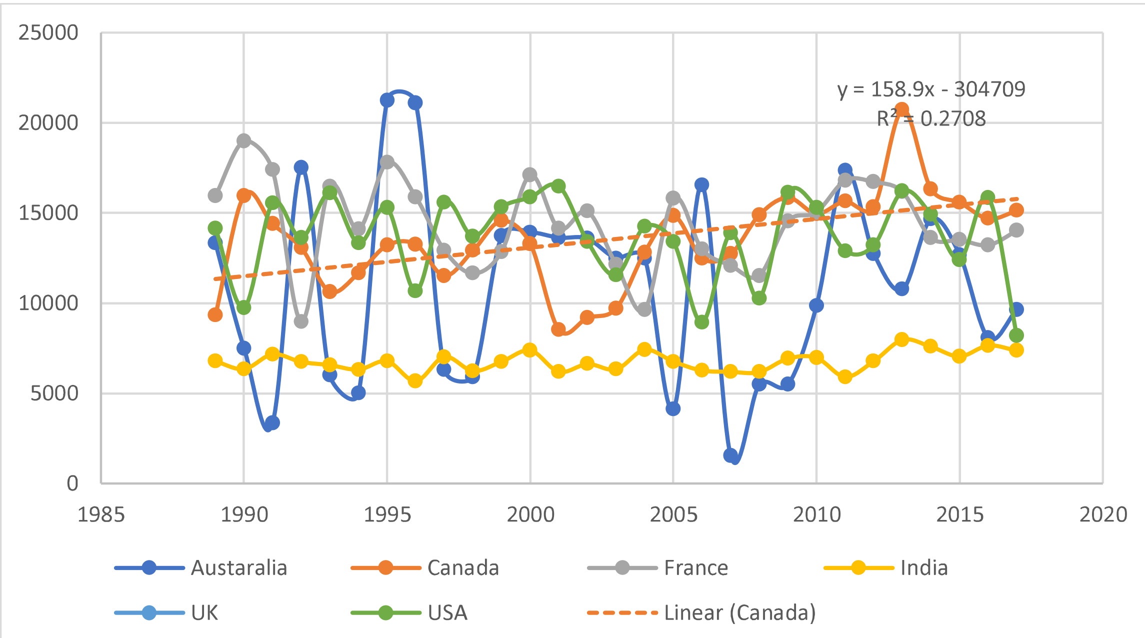

Figure 5 Lentils Yield in hg/ha in Australia, Canada, France, India, UK and USA, 1989 to 2017
Source: FAOSTATS 2019

GenomeCanada

Agile
APPLICATION OF GENOMICS TO INNOVATION IN THE LENTIL ECONOMY

GenomePrairie

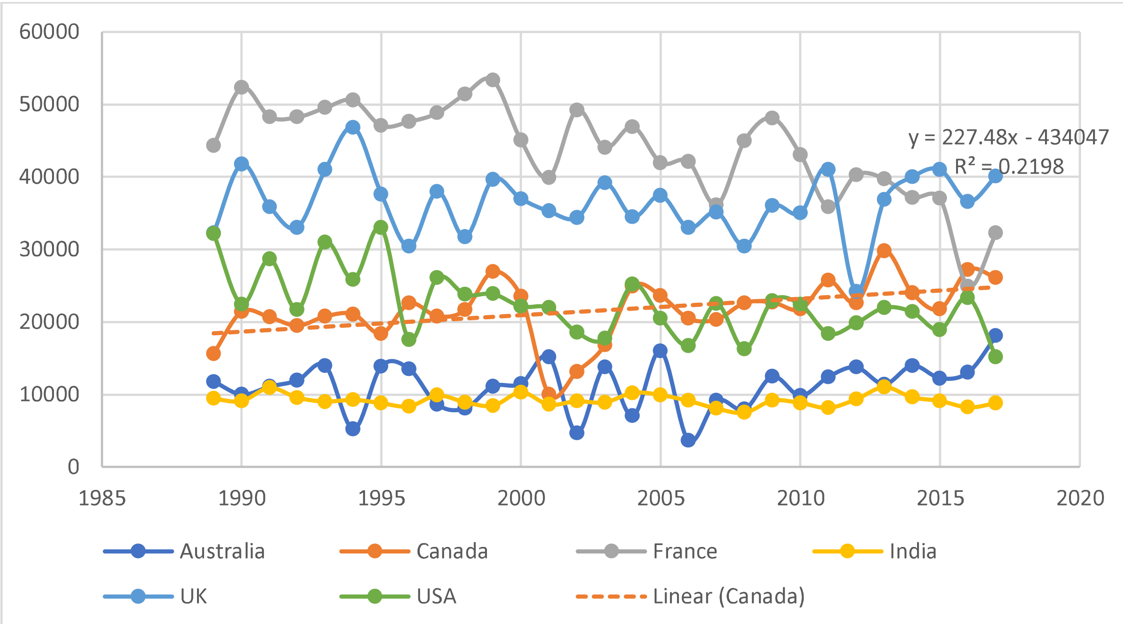

Figure 6 Dry Peas Yield in hg/ha in Australia, Canada, France, India, UK and USA, 1989 to 2017
Source: FAOSTATS 2019

The annual investment in pulse crop variety development in western Canada averaged $8.5 million over the decade 2002 to 2011, with Agriculture and Agri-Food Canada (AAFC), provincial governments, and producers accounting for 35%, 23%, 33%, respectively (Pidskalny 2012; Carew, Florkowski and Zhang, 2013). There is very limited private sector investment by multinational enterprises in the development of new pulse varieties in Canada with one exception being Clearfield lentils which are developed via a producer/university/private sector partnership (BASF 2012). In this partnership, the CDC breeds the Clearfield herbicide resistant trait into SPG-funded elite lentil varieties in return for royalties from BASF, which then earns additional income from their Odyssey herbicide sales.

1.3 Pulse Growers Associations

Innovation has been vital for the success of the pulse sector in Canada. In the 1970s and 1980s, there was a demand for new pulse cultivars that were herbicide resistant and disease resistant. Better farm machinery for seeding and harvesting pulse was also necessary. In response to those needs, producer organizations such as the Saskatchewan Pulse Growers, the Manitoba Pulse Growers and the Alberta Pulse Growers were created. In 1984, Saskatchewan Pulse Growers (SPG) (currently representing 18,000 producers) was established as a grower funded and controlled organization. The Manitoba Pulse Growers Association (3000 members) and the Alberta Pulse Growers (APG) (4700 producers) were established in 1983 and 1989, respectively. These organizations have financed much of the pulse research undertaken by public institutions in the prairies.

SPG collects a compulsory and non-refundable check-off from growers in Saskatchewan on the sale of pulse crops to fund development of the pulse sector. The check-off has varied over time and is currently 0.67 percent of the value of the sale. The check-off revenue is primarily invested in research, development, and extension activities. SPG contributed meaningfully to areas such as a pulse crop genetic improvement, plant disease management, inoculants, fertilizers, feed use, product quality, weed and insect control, machinery and facilities, and general agronomic research. The priority has been on pulse crop genetic improvement. Some of SPG activities have produced early dividends while others, such as the genomic research to develop new varieties, are long term efforts which take 10 years or longer to pay dividends (Gray and Scott, 2003).

Alberta Pulse Growers and the Manitoba Pulse and Soybean Growers Association are collecting a compulsory but refundable levy and the rate is 1.0% and 0.5%, respectively. Refundability causes some free riding problems and those organizations are not as successful in financing research as SPG is (Carew, Florkowski and Zhang, 2013).

Since 1997, the SPG has worked only with the Crop Development Center (CDC) in pulse breeding. The SPG is a major funder of the CDC and thus CDC varieties are exclusively licensed to the SPG for commercialization (Serfas and Gray, 2018). The SPG distributes the CDC varieties through seed growers in Saskatchewan and partners with other companies, such as SeCan and SeedNet, to distribute CDC lentil varieties outside of Saskatchewan (Serfas and Gray, 2018).

Gray and Scott (2003) evaluated the gains from the activities of the SPG, estimating the economic impact of the SPG research and development activities by measuring the costs and benefits for producers, consumers and value-added sectors. Gray and Scott (2003) found the benefit/cost ratios to be quite high. In the 1984-2008-time period, the benefit/cost for growers was 13.46 to 1.0 when the combined impacts from genetic improvement and the acceleration of development created by SPG activities were taken into account. This ratio means that in the 1984-2008-time frame for every $1.00 of cost borne by growers, they received $13.46 in producer surplus. A later study by Gray et al. (2008) found the benefit/cost ratio for growers to be even higher; 15.8:1 for the time period 1984-2008 and 20.2:1 for the time period 1984-2024. Groenewegen, Thompson, and Gray (2016) found that benefit/cost ratios for lentils and peas at the CDC are even higher, greater than returns for all CDC's crop kinds varieties. They found benefit/cost ratio for lentil to be 48.7 and IRR 23.2%, for field peas benefit /cost ratio 25.6 and IRR 15.9%.

1.4 The Crop Development Center

The Crop Development Center (CDC) is a field crop research organization in the Department of Plant Science at the College of Agriculture and Bioresources. Connection with University of Saskatchewan enables access to the relevant scientific and technical disciplines and resources necessary to develop crops for food and feed. The CDC scientists also cooperate with numerous Canadian and international public and private organizations gaining additional technical and financial resources to advance research. The CDC was launched with an objective to advance economic returns for growers and the western Canadian agricultural industry through improving crops that already exist, finding different uses for traditional crops, and creating new crops. The CDC scientists integrate basic research with genetic improvement using scientific advances in plant breeding and pathology, agronomics and end use performance of spring wheat, durum, canaryseed, barley, oat, flax and field pea, lentil, chickpea, faba bean, and dry bean (Crop Development Center, 2019). The majority of pea and lentil varieties cultivated in western Canada have been developed by the CDC (CGC, 2018).

In western Canada, the CDC develops about 99% of the lentil varieties in terms of insured hectares and has developed the top 10 lentil varieties. In 2017, the main lentil variety in western Canada is CDC Maxim, followed by CDC Impower CL, CDC Invincible CL, CDC Proclaim, CDC Greenstar, and CDC Dazil. The CDC also develops about 91% of pea varieties in terms of insured hectares in western Canada. The main pea variety cultivated in western Canada is CDC Meadow, followed by CDC Amarillo, CDC Saffron, and CDC Golden (Serfas and Gray, 2018).

In 2006-2016, about 71% of research money in pulses at the CDC went towards peas and lentil breeding (Serfas and Gray, 2018) with the remainder split between chickpeas, dry beans and soy beans.

The CDC is funded by producer organizations, federal appropriations, and research grants. The SPG has been the largest contributor to the CDC, followed by Natural Science and Engineering Council of Canada (NSERC). NSERC grants are provided to fund Industrial Research Chairs (IRC) and to partner with industry. The Agricultural Development Fund (ADF) also funds the CDC to improve agricultural research and to increase competitiveness in the agricultural industry. This fund is provided through the Saskatchewan Ministry of Agriculture which also funds Strategic Research Program (SRP) Chairs (Government of Saskatchewan, 2018).

Peas, chickpeas, and non-Clearfield lentils are protected by plant breeders' rights. Seed of those varieties is provided to Saskatchewan producers royalty free because their breeding program is supported by check-off levies (Serfas and Gray, 2018). Certified seed sales of these varieties outside of Saskatchewan are subject to royalties. However, the practice of brown bag seed sales often dilutes the value of the IP.

1.5 National Research Clusters

Pulse R&D has also benefited from three national pulse research clusters, (2010-13, 2013-18, 2018-23), each funded by the federal government, provincial governments, Pulse Canada and all provincial pulse producer organizations. These partnerships address pulse industry priorities of productivity growth and nutritional enhancement to enable the sector to remain internationally competitive (Carew, Florkowski and Zhang, 2013; Pulse Canada, 2019). Leftwich (2018) reported investment into the 2018 Pulse Science Cluster from Canadian Agricultural Program (CAP) AgriScience Cluster program (C$11.1 million CAD); from the Saskatchewan Pulse Growers (C$1.5 million CAD), and from industry (C$7.2 million CAD). All researchers from universities or other not-for-profit organizations can apply to the Cluster for research funding by applying to the Saskatchewan Pulse Growers (Manitoba Pulse and Soybean Growers. 2016).

The Pulse Cluster program supports the pea breeding program at AAFC (a co-funding model between AAFC and Alberta Pulse Growers). Producers (both AB and SK) need to pay a royalty when they want to use AAFC varieties.

In addition to these National Clusters, the pulse industry has also benefitted from large scale Genome Canada projects which have been cofounded by producers, industry and governments. Thanks to these projects, researchers at the CDC have played leadership roles in the first complete sequencing of peas, lentils and wheat. The Genome Canada projects have also been instrumental in developing molecular markers for the selection of many desirable rates including biotic and abiotic stress resistance.

1.6 Variety Commercialization

Since 1997, the development and commercialization of pulse varieties in Saskatchewan has occurred under two programs: SPG Variety Release Program and the Tender Release Program. In case of the Variety Release Program, the SPG supports the CDC's pulse-breeding program with an average of C$1.8 million per annum and in return, the CDC gives SPG exclusive rights to distribute all the pulse varieties developed by the CDC. Under the second program, the Tender Release Program, specialty pulse varieties differentiated by end use characteristics are tendered to seed companies by the SPG for a royalty. Private companies awarded the rights manage the commercialisation of these varieties. As of 2011, the vast majority of new varieties have been released under the Variety Release Program (95 varieties: 38 lentil, 29 pea, 20 chickpea, 7 common bean and 1 faba bean) with only eight varieties (5 bean, 3 lentil) released under the Tender Release Program (Carew, Florkowski and Zhang, 2013).

Despite past successes in breeding, the demands for additional growth of breeding investment is likely to persist, raising the question of whether the current check-off levy funding system is able to generate sufficient research funds post-2020. Serfas and Gray (2018) found if the pulse breeding sector were to maintain the status quo with the checkoff levy system, the industry will forego significant additional long-term benefits. To fully benefit from the expansion in pulse markets, more investment is needed.

2.0 International Models of Royalty Collection

2.1 Global production

India is the world's largest producer of pulse crops with pulse production dominated by chickpeas, cow peas, and pigeon peas. Despite India's production, their diet and large population has also made them one of the largest importers of pulse crops. IPRs are typically weak with producers typically relying on publicly bred varieties with a dominance of farm saved seed.

As previously mentioned, and as shown in Figures 1 and 2, Canada now leads the world in lentil and pea production. Canada, Australia, and Turkey are the main world exporters of chickpeas and lentils. Canada, Europe, Australia, and the United States are the major exporters of dry peas.

Pulse area and production has trended up in Australia. While being moderately successful in producing and exporting dry peas and lentils, Australia has become a major exporter of chickpeas.

Led by France in 1990, the European Union (EU) dominated world dry pea production. As shown in Figure 1, this production subsequently collapsed to about 10% of peak levels due to the outbreak of aphanomyces root disease in France. In past decade, the area of pulse crop production has fluctuated but has increased significantly since 2013. Between 2013-2015, the area of pulses increased in the EU by 64.7%. The growth was largely caused by the new Common Agricultural Policy (CAP), which since 2015, introduced the green direct payment for nitrogen-fixing crops.

In 2015, the EU planted 2.2 million hectares of pulse crops making up 2.1 % of the total arable land. Of this seeded area, 22.5% was in Spain, 18.6% in Poland, 12.4% in France and 9.8% in the UK. Despite ranking 4th in terms of areas, France was the largest EU producer of dry pulses producing 930 000 tonnes, UK, ranking 4th in terms of area, was 2nd in production, making up 17.9 % of production volume. France and the UK specialize in the more productive dry pulse crops such as field peas and broad beans, whereas, Spain has huge areas of the heterogeneous 'other dry pulses'. Moreover, the farms cultivating dry pulses in France and the UK are larger and therefore experience economies of scale (DeCicco, 2016).

Different countries in the EU dominated the production of different pulse crops. In 2015, France had the largest area and the largest production of field peas, producing 662,000 tonnes or 31.9% of the Union total. The UK had the largest area and was the largest producer of broad and field beans producing, 740,000 tonnes or 37.8% of the EU total (DeCicco, 2016).

Given that the UK, France and Australia have a longer history of UPOV 91 compliance, and each has success at least one pulse crops, we will examine the way in which these countries have implemented UPOV 91.

2.2 Financing of Pulse Breeding in the UK

In the UK, breeders are granted a form of intellectual property rights called Plant Variety Rights for all new varieties. The holder of this intellectual property has a right to collect royalties when a protected variety is sold as certified seed or when it is used as Farm Saved Seed (FSS) (BSPB, 2019). The UK has been a member of UPOV since August 10, 1968 and acceded to the UPOV 1991 convention on January 3, 1999 (UPOV, 2019b).

Pulse breeding in the UK is royalty financed and done by the commercial plant breeding companies. The pulse breeding companies, which are members of British Society of Plant Breeders, (BSPB) include: Limagrain UK Ltd, KWS UK Ltd, Senova Ltd (breeding at IBERS), Saaten Union, Elsoms, Agrii, RAGT, and LS Plant Breeding. How much of the royalty is invested back into plant breeding varies by company but it tends to be about 25-30% directly reinvested in R & D (Maplestone, 2019).

The Department for Environment Food and Rural Affairs (DEFRA) supports a Pulse Crop Genetic Improvement Network (PCGIN) to bring researchers together. There is also some public sector funded research on pea genetics at the John Innes Centre however all breeding of finished varieties is done by private sector (Maplestone, 2019).

BSPB operates a centralised licensing system for certified seed production and sales of field peas and beans. BSPB in the names of its members[1] gathers royalties on sales of certified seed of protected varieties of cereals, potatoes, grasses and pulses. BSPB is also collecting royalties on FSS use of protected varieties. The FSS collection for combinable crops (that includes peas and beans) is done following the rules agreed upon by BSPB, National Farmers Union, National Farmers Union Scotland and the Ulster Farmers Union. BSPB is collecting royalties on varieties that are protected by UK or EU PVR (BSPB, 2019). Typically, FSS royalties are paid to BSPB-registered seed cleaners as a part of the processing invoice. However, farmers can also pay directly to BSPB. The royalties on FSS that has been *self-processed*, *cleaned by a non-registered processor*, or *sown straight from the barn*, are compulsory and paid directly to BSPB (BSPB, 2019).

There is also an alternative scheme operating in the UK, which some breeders choose to use for royalty collection on some of their pea and bean varieties. This is the Royalty Area Collection (RAC) scheme, a contract-based system run by the Breeders' Intellectual Property Office (BIPO). The principle is that the certified seed is sold to the farmer royalty free with a per hectare payment due on sowing. The farmer enters into a contract on buying the certified seed that sets the payment rate for certified/FSS royalty and obliges him to be subject to audit. The payment rate is the same whether the crop is sown from certified or FSS and is set by the breeder (Maplestone, 2019).

According to British legislation, farmers are legally obliged to declare their use of FSS and to pay royalties if they use registered varieties. They can save seed only if it has been grown within a farmer's own business (i.e. land farmed as the same business). Farmers can't sell, buy, barter or transfer FSS in any way. FSS rules apply whether seed has been processed or taken straight from the barn. The seed from hybrid varieties can't be farm-saved without the breeders' permission (BSPB, 2019).

[1] Plant breeders and breeders' agents who are marketing varieties of cereals, oilseeds, potatoes, vegetables, sugar beet, fodder and forage crops, amenity grass and pulses in the UK (BSPB, 2019).

Certified seed royalty rates are set individually and independently by the breeders for each variety and are notified to BSPB annually. The rates are commercially confidential and are not published except to production and sales sub-licensees on a need to know basis. Certified seed royalties are not refundable (Maplestone, 2019).

For 2019, the FSS royalty rate on seed processed by BSPB registered cleaners is £42.61/t (C$69.63/t) for peas and £59.38/t (C$93.03/t) for beans. For areas sown with FSS not processed by BSPB registered cleaners, the royalty rate for peas is £9.51 /ha (C$15.54 /ha) and for beans £13.49 /ha (C$22.04/ha). These rates are calculated in the way consistent with an agreement between BSPB and the farming unions. Rates can change every year (BSPB, 2019).

New varieties have to pass registration trials before they can be sold in the EU. They must meet DUS (Distinctness, Uniformity and Stability) requirements and VCU (Value for Cultivation and Use) trials to warrant they satisfy high standards of quality and performance. For the majority of crops, after legal registration, additional industry trials are undertaken at additional locations. The objective is to identify the best varieties to be endorsed onto a Recommended List.

BSPB has been granted rights to run VCU trials for majority of crops for UK National Listing purposes (BSPB, 2019).

In the UK, there are no check-off levies on pulse crops in relation to the funding of plant breeding. Processors and Growers Research Organization (PGRO) operates a voluntary levy scheme for growers, the money raised is used to fund PGRO's own pulse crop research, market development and generic promotion (Maplestone, 2019).

2.3 The Financing of Pulse Research in the France

As explained before, France is the largest EU producer of dry pulses, producing 930,000 tonnes equal to 18.1% of total EU dry pulses. While the pea production remains significant**,** *aphanomyces* root rot has been a major problem for peas producers in France, reducing production from a peak of 3.5 million tonnes in 1990. France currently has the largest share of field peas areas with 23.6% of total field pea area in the EU. It is also the largest producer of field peas in terms of volume, producing 662,000 tonnes equal to 31.9% of the EU's field peas production. The farms cultivating dry pulses in France are large, enabling them experience economies of scale (DeCicco, 2016).

The primary source of royalty income is related to certified seed sales. Breeders typically earn a per tonne seed royalty whenever seed from their variety is sold to a farmer. Plant Variety Certificates (PVC) assure plant breeders property rights for a period of 25 to 30 years, depending on the species. Prior to 2011, using FSS theoretically was prohibited, however in practice it was tolerated. In 2011, the government passed a law which made FSS legal for some species if a royalty was paid to breeder (Bolis, 2012). The system was extended in 2011 and 2014 and consequently, under EU's rules and French legislation, farmers are allowed to use FSS for 34 species, including lentils and field pea, in exchange for a *fair remuneration for breeders* (Bolis, 2012; SICASOV, 2019). The amount of remuneration is contract based. French law specifies that farmers who wish to use FSS from protected varieties can sign a contract with plant breeders or with breeders' representatives (usually the SICASOV). Despite this law and contract provisions, some unpaid FSS continues to exist in pulse crops which reduces the amount of royalty collected. These collection issues, combined with the relatively small acreage base, has limited the private investment in pulse breeding which in turn makes it difficult to expand pulse crop area.

While the FSS collection issues persist in pulses, the issue of collecting royalties on FFS has been addressed in wheat. Since 2001, France has used a Compulsory Voluntary Contribution (CVO) for soft wheat. The CVO is a uniform end point royalty which farmers must pay when they deliver their crop (Currently the rate is €0.7 /t). After CVO is collected, farmers producing less than 92 tonnes or farmers that can demonstrate they are growing an unprotected variety, can apply for a complete rebate of the royalty. Also, farmers who purchased certified seed can apply and obtain a refund of €20 ($C27.60) per tonne of purchased seed. Once rebates are all paid, 85% of the collected money is given to a property rights management organization for plant breeders, GNIS. GNIS works with SICASOV to distribute the royalties to breeders in proportion to breeders' varieties' shares of certified seed sales. The rest of the money collected from the

CVO (15%) is dedicated to support public wheat research (Talvaz, 2013; Gray and Galushko, 2013; Bolek, 2015). In 2011, the COV system was extended to all types of wheat. The simplicity of the CVO royalty collection makes it a potentially attractive model for royalty collection in Canada.

Despite limited royalty collection for pulses, France continues to actively develop pulse varieties through public research and a number of national and international research consortiums (INRA, 2019). The Institute National de la Recherche Agronomique (INRA) is Europe's top agricultural research institute and the world's number two center for agricultural sciences. Agri Obtentions, the public breeding arm of INRA, is carrying out a breeding program on field beans (winter and spring) and winter peas. The INRA Unit in Dijon use its national genetic resource collections on pea, field bean and lupin for research programs on sequencing of the pea genome.

2.4 The Financing Pulse Research in Australia

Pulses are a vital crop in Australia and it is now the norm to include them into the crop rotation system (Bartelen, 2016). Australia produces about 2.2 million tonnes of pulses on 1.8 million hectares or about 10 percent of the total arable land (AEGIC, 2018). Pulse crops are cultivated throughout the southern and northern regions in the crescent, known as the Australian grain belt. The largest pulse crop in Australia is lupin with annual production of approximately 500,000 tonnes, equal to about 30-40 % of total pulse crop production. Field pea is the dominant pulse crop in southern Australia with annual production of approximately 300,000 tonnes, equal to about 10-15 percent of Australia's total pulse production. Lentils are produced almost solely in South Australia and Victoria. Annual lentil production is approximately 250,000 tonnes, equal to about 10-15 percent of total pulse production. Figure 8 shows historical production of peas and lentils in Australia. Australia is a major exporter of high-quality lentils (AEGIC, 2018) and the world's largest exporter of chickpea and lupins (FAO, 2012). Also, approximately 55 percent of domestic field pea production is exported.

Australia is known for having one of the most effective systems of supporting its high-quality breeding programs. Until 1980, pulse production in Australia was low and only field peas and lupins were cultivated. During the next decade, chickpeas, faba beans, and lentils were adopted (Khan, 1989). The pulse crops area expanded, the investment in breeding increased and new, improved varieties were released. During that time breeding was mainly conducted regionally by state agencies and universities. The Grain Research and Development Corporation (GRDC), established in 1990, has played a critical role in the system of funding agricultural research. The GRDC does not conduct research directly but invests in projects and oversees R&D and Extension. GRDC is the leading grains research organization supporting growers, improving yield, increasing production and profitability of the Australian grains industry (GRDC, 2019a). The GRDC is funded by a growers' levy of 1.02% of farm gate value of production paid on 25 crops including pulses which is then matched by government on a dollar-for-dollar basis up to 0.5 % of the three-year rolling average of gross value of production (Bolek, 2015).

In the mid-1990s, there was a move to create a national pulse breeding program which led to establishment in 2006 Pulse Breeding Australia (PBA) network. PBA is an unincorporated joint venture between GRDC, Pulse Australia, state government agencies[2], the Universities of Adelaide and Sydney. PBA has a nationally coordinated breeding program that is dedicated to development and testing of new pulse varieties and aims to centralize Australia's' pulse breeding R&D and prioritize grower, marketing, and customer needs. Its vision is to increase productivity, profitability and sustainability of Australian grain farming systems by trying to improve efficiency of pulse breeding, increase the speed of genetic gain and facilitate exchange of germplasm and intellectual property rights among partners (GRDC, 2019a; Pulse Australia, 2019; Paull, 2016). PBA has a coordination group which includes: breeders and researchers, an advisory board with a member of each investor, a coordinator, and crop breeding groups which have facilitated communication across all levels. The breeding programs exchange ideas, coordinate trials, prioritize GE programs and outputs.

[2] Department of Primary Industries in Victoria (DPI Vic), South Australian Research and Development Institute (SARDI), Department of Agriculture and Fisheries Queensland (DAF Qld), New South Wales Department of Primary Industries (NSW DPI), Department of Agriculture and Food Western Australia (DAFWA) (GRDC, 2019a).

Pulse Australia, one of the members of PBA, is an industry body that represents all sectors of the Australian pulse industry. It is independent, non-political, and comprised of members of different areas of interest including marketing and exporting, merchandising, research, and farming (Pulse Australia, 2019). The objectives of Pulse Australia include: to maintain and expand markets, to improve the pulse value chain, to provide coordinated leadership and planning, to ensure reliability and safe production (Pulse Australia, 2019). Australian pulse standards and classifications are updated and governed by Pulse Australia (AEGIC, 2014).

Most pulse breeders (apart from AGT's lupin breeding) work in the public sector, especially in state government agricultural agencies. The Victorian government agency (Vic DPI) has a strong commitment to pulse breeding (especially lentils, field peas and chickpeas). EPRs flow back to these organizations as developers of the new varieties and those revenues are used to provide on-going support for pulse breeding (Kingwell, 2019). Some of the largest pulse PBR owners in Australia include Seednet, AGT, PB Seeds, and Heritage Seeds to name a few. The Department of Primary Industries in Victoria (Vic DPI) and the University of Adelaide are also involved in pulse breeding (Variety Central, 2019). GRDC and state governments also provide funding support for many pulse breeding programs (Kingwell, 2019).

Since 2016, AGT has taken on the role of Australia's breeder of lupins. The former Department of Agriculture Western Australia and its lupin breeding program no longer exist. The WA Department of Agriculture was amalgamated with two other departments (Fisheries and Regional Development) to form a multi-function department known as DPIRD (Department of Primary Industries and Regional Development). Lupin breeding by the WA Department of Agriculture (i.e. publicly funded) was discontinued and that role is now provided commercially by AGT (Kingwell, 2019).

Carew, Florkowski and Zhang (2013) reported Australia research investments in core pulse breeding average about C$10.3-12.4 million per year for nine pulse-breeding programs. The GRDC research expenditure share was about 50%, with the remining part financed by main research providers such as Universities and state departments of agriculture (e.g., New South Wales).

Until Australia could demonstrate a certain annual production capacity and quality, markets were limited. Today, Australian pulses are highly regarded around the world (Bartelen, 2016).

IPRs for plant varieties in Australia were primarily created by the Plant Variety Rights Act of 1987 (Kingwell, 2005; Kingwell and Watson, 1998). The Plant Variety Rights Act 1987 had a small impact on breeding as it did not apply IPRs to FSS. Farmers in Australia were sowing primarily FSS, consequently industry had rather limited returns. To conform with UPOV 91, the Australian Parliament passed the Plant Breeders' Rights Act 1994 (IP Australia, 2019). Breeders' rights were extended to harvested material. It allowed plant breeders to obtain revenue by imposing EPRs. Producers who are authorised to grow a variety contractually agree to pay EPRs on harvested material. If producers fail to pay the EPR, the legislation empowers breeders to enforce their rights on harvested material (Bolek, 2015).

Australian plant varieties can be protected under the Australian Plant Breeders' Rights Act 1994 (the PBR Act) and the Australian Patents Act 1990. Breeders can apply for both systems of protection, however, most varieties are protected under the PBR Act (Myers, 2017).

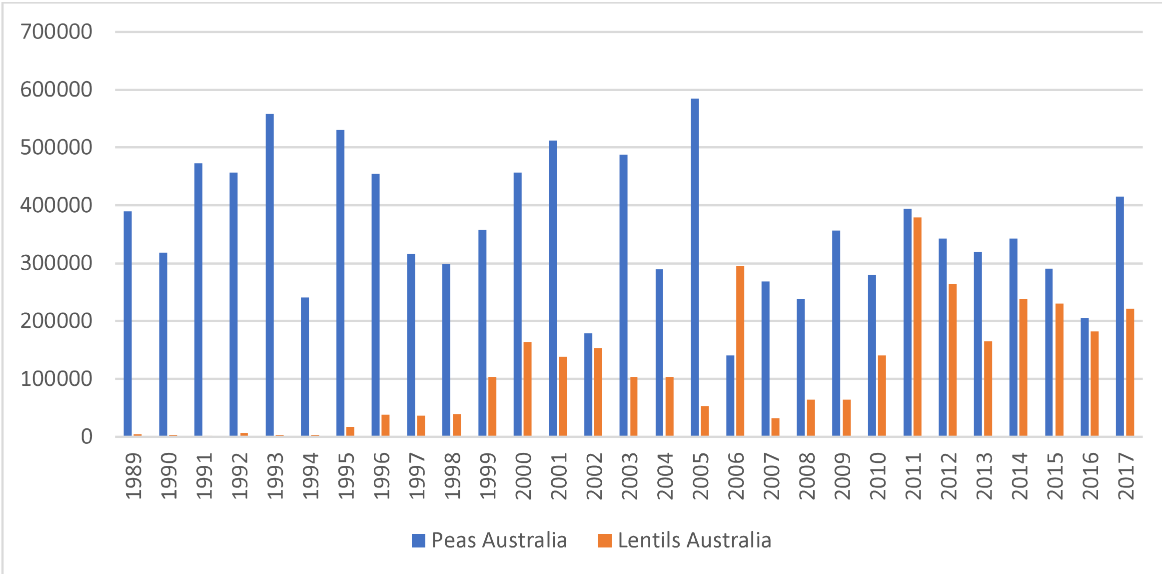

Figure 7 Dry Peas and Lentils production in tonnes in Australia in years 1989 -2017. Source FAO STAT 2019

An End Point Royalty (EPR) is a value capture mechanism used by breeding companies to obtain a return on investment. It is a risk-sharing option, where growers pay a royalty based on production. This means breeders are rewarded for producing the most successful varieties and encouraged to innovate (Variety Central, 2019). In Australia, the first varieties with EPR were released in 1996. At the moment, there are over 180 varieties of cereals, brassicas and pulses with EPRs in the Australian market (Variety Central, 2019).

The plant breeding organizations in 2007 created a group named the EPR Steering Committee. The objective of the committee was to create an effective and efficient system to collect EPRs. Grain traders are an important part of EPR collection system. They can take part in the collection system in two possible ways: the EPR can be deducted by a grain trader from the grower's grain payment and forwarded to the variety owner; or where grain traders do not have the capability to deduct EPRs, breeding companies can create a system where traders deliver to the breeding company/royalty managers, the data on grower purchases and the breeding companies/royalty managers send out invoices directly to the growers. This system is also used for growers who use the grain on their own farm. In that case, the grower make data available to the breeding company/royalty manager via the EPR Harvest Declaration Notices (Walmsley, 2011; GRDC, 2011; Bolek, 2015).

Accurate variety declaration is both a legal and contractual obligation. First of all, a *mis-declaration* of a *variety* is a breach of the PBR Act and may result in *fines* of up to $55,000 for an individual and $275,000 for a company. Second, if required by the variety owner it a breach of a contractual obligation. (GRDC, 2019b). Grower compliance is key to ensure returns to plant breeders, to facilitate development of new varieties, to guarantee competition in the breeding industry, and to increase productivity and quality. To simplify the declaration process, the major seed companies created the Grower Harvest Declaration form. Variety owners and royalty managers also use Bulk Handler Reports and Grain Trader Reports to monitor EPR compliance (Bolek, 2015; Variety Central, 2019).

The variety owner and the growers use the variety licenses which are legally binding contracts specifying the terms and conditions the grower needs to follow when using a new variety.

Each variety owner sets EPR rates for his varieties. For peas, EPR rates range between AUD 1.20/t (C$1.10/t) and AUD 5.00/t (C$4.57/t). For lentils, EPR rates are set at AUD 5.00/t (C$4.57/t). Average annual production of dry peas in Australia over the last ten years was approximately 314,000 tonnes and average annual production of lentils over the last ten years was approximately 180,000 tonnes. Thus, Australia collects about AUD 900,000 (C$822,348) EPRs on lentils and about AUD 973,400 (C$889,415) in EPRs on peas, assuming an average EPR of AUD 3.10/t (Author calculation based on FAOSTAT data).

A number of companies are core to managing this system:

Seednet, a company that specializes in the commercialization of many breeders' pulse varieties, is a commercial partner and royalty manager for many pulse varieties (Kingwell, 2019).

Australian Grain Technologies (AGT) has a network of professional seed growers and processors across Australia. Professional seed growers are responsible for production, grading, sales and distribution of all AGT varieties. Farmers access varieties through these affiliates' vs directly through AGT. AGT allows seed sharing between farmers provided one has grown a crop from AGT and has agreed to the AGT Seed Sharing License Agreement (AGT, 2019).

Heritage Seeds is a seed company driven by significant investment in research and development. Seedmark is also part of Heritage Seeds. Heritage Seed staff administers the EPR collection on behalf of breeders (Heritage Seeds, 2019).

NuSeed is an Australian owned and operated seed company. NuSeed is involved in breeding, development and commercialization of crops (NuSeed, 2019).

PB Seeds is vertically integrated from the production of seed, processing, packaging, and marketing seed and grain. PB Seeds has been involved in pulses over 20 years. PB Seeds is the commercial partner to PBA for the release of PBA lentil varieties across Australia. This collaboration delivers lentils 2-4 years earlier than others to growers by fast tracking identification, multiplication, and release of new varieties (PB Seeds, 2019).

PGG Wrightson Seeds undertakes seed production and research and has numerous partners within Australia and internationally (PGG Wrightson Seeds, 2019).

3.0 The Economic Implications of Alternative Royalty Systems for Pulses in Canada

3.1 Introduction

After reviewing pulse breeding systems in the UK, France and Australia as well as the Canadian status quo, four potential paths for Canadian implementation of UPOV 91 for pulse variety development seem plausible. Considered paths for Canada include: Canadian status quo; UK-style system with royalties on FSS (by industry referred to as a trailing royalty); French-style system with uniform EPR rates; or an Australian-style system with competitive EPR rates. The timeline when royalties are being generated differs among proposed options. An Australian styled system would lead to a lag in generating royalties because only new varieties would have EPR rates attached to them and they would have to compete with older free varieties present in the market. Therefore, the revenue from EPR would grow rather slowly. Generated royalties could be used for the breeding of new varieties and therefore benefit the industry; over time the Australian approach converges on the others. Comparison of each pathway with its possible economic implications enables evaluation related to each scenario policy choices.

3.2 The Base Comparison of Royalty Systems

To conduct analysis of four scenarios and to compare them we have used a number of simplifying assumptions:

- There is no change in the level of the producer check-off and public funding over analyzed period of 40 years;
- Every marginal dollar invested in breeding creates the same stream of upcoming benefits. Specifically, the real pulse prices and pulse area stay unchanged and the benefits from an investment in breeding, similar to Gray et al. (2017), are assumed to be zero until year 8, then to increase linearly and to peak in year 12. After that benefits are assumed to decrease at 10% per year rate until year 40 when they completely disappear. This pattern of benefits is then discounted at a 5% real discount rate and scaled to create a 13.5:1 benefit/cost ratio for each dollar invested in breeding. The 13.5:1 benefit/cost ratio is taken from the Gray and Scott (2003) study of return to research of SPG.
- The net present value (NPV) of the investments is calculated for 20, 30, and 40-year periods; and

- The NPV of the pathways is calculated for 30%, 60% and 90% of the royalty stream being invested into pulse breeding.

The considered scenarios were constructed as follow:

A) Status quo

Carew, Florkowski and Zhang (2013) reported that total annual investment in pulse development in Western Canada over the years 2002-2011 was on average C$8.5 million, with AAFC, provincial government and producers investing 35%, 23% and 33% respectively. In this scenario, it is assumed the real investment stays at that level for the next 40 years. The status quo would dominate if producers oppose the introduction of royalties so that the public breeding institutions could not access any new royalty streams.

B) Trailing Royalty - Royalties on Farm-Saved Seed (UK)

In this scenario, it is assumed that a royalty is imposed on certified seed and on FSS. The FSS royalty rate is equal to 50% of the certified seed rate. To calculate demand for seed, we used seeding rates and seeded area. The seeding rate for lentils reported in the SPG production manual for 2000 was 65 kg/ha and for dry peas 40 kg/ha. The seeded area for lentil in 2017 was 2,467,763 ha and for dry peas was 1,773,282 ha (FAOSTATS, 2019). We used an FSS royalty rate of C$65 /tonne for dry peas and C$23 /tonne for lentils based on the assumption that 1 tonne of seed produces approximately 65 tonnes of dry peas at harvest and 1 tonne of seed produces approximately 23 tonnes of lentils at harvest (as a check, the FSS royalty rate for peas in UK is about C$70 /tonne). Given that approximately 60% of hectares are sown with FSS, the overall calculated royalty revenue is C$11.62 million per year. The development of this system would need some changes to the Seeds Act and the development of a mechanism to collect royalties on FSS.

C) Uniform EPR (France CVO)

In this scenario, a uniform EPR of C$1/tonne is imposed on the sale of all pulse varieties. Those royalties are passed to plant breeders in proportion of their varieties' share of marketed pulse. Producers that use certified seed receive a rebate equal to half the average seed royalty. With an expected production of 8.4 million tonnes (lentils and dry peas) (FAOSTAT, 2019), this would generate C$11.68 million of combined seed royalty and EPR revenue, beginning in the first year of implementation. The development of this system would require strong support from pulse producers, an agreement by pulse breeders to introduce the uniform EPR and a change in Plant Breeders' Rights regulations. The EPR collection mechanism could be similar to the check-off collection mechanism currently in place.

D) Competitive EPRs (Australia)

This scenario has an EPR system similar to the Australian system. Only new pulse varieties, not existing varieties, would have EPRs attached to them. Moreover, the royalty rates would vary by variety. The time frame for revenue generated by royalty is assumed to have the same pattern as the Australian wheat EPR: six years before some revenue is experienced, then an annual increase of C$.18/t each year after year 6. The sum of peas and lentil production in 2017 was 8.4 million tonnes (FAOSTATS, 2019). This path assumes breeding programs start to gradually implement the EPRs through the use of seed purchase agreements and collection and enforcement systems as in Australia. The introduction of such a system in Canada would need regulatory change, the development of a royalty collection system and a common move by variety owners to use EPRs.

The revenue generated from royalties in each scenario is shown in Table 1. Scenarios B, C, and D all raise more revenue than the status quo. The Australian EPR Scenario D reaches a much higher level than the French EPR Scenario C or UK FSS (Trailing Royalty) Scenario B, however generation of revenue is delayed as new varieties have to compete with the royalty-free farm-saved seed of existing varieties.

Table 1: ***Maximum Potential Pulse Variety Royalty Generation by Pathway 2019-2058***

Year	A Status quo[1]	B Farm-saved seed royalty[2] (UK)	C Uniform EPR[3] (CVO France)	D Comp. EPR[4] (Australia)
	(C$Million/yr)			
2019	0.00	11.62	11.68	0.00
2020	0.00	11.62	11.68	0.00
2021	0.00	11.62	11.68	0.00
2022	0.00	11.62	11.68	0.00
2023	0.00	11.62	11.68	0.00
2024	0.00	11.62	11.68	0.00
2025	0.00	11.62	11.68	1.51
2026	0.00	11.62	11.68	3.02
2027	0.00	11.62	11.68	4.54
2028	0.00	11.62	11.68	6.05
2029	0.00	11.62	11.68	7.56
2030	0.00	11.62	11.68	9.07
2031	0.00	11.62	11.68	10.58
2032	0.00	11.62	11.68	12.10
2042	0.00	11.62	11.68	27.22
…				
2052	0.00	11.62	11.68	42.34
…				
2058	0.00	11.62	11.68	51.41

Source: Authors' estimates

1 Status quo – current investment of C$8.5 million from public sources and producer check off continues.
2 Farm-saved seed rate C$65 /tonne for dry peas and C23 /tonne for lentils =50% of seed royalty rate.
3 Uniform EPR of C$1/t.
4 EPR revenue pathway similar to 1994-to-present Australian pattern.

3.3 Sensitivity Analysis of Research Investment

It is important for our analysis to describe how much additional royalty will be collected and, in turn, be invested. For this calculation reason, we need to define the following terms, which are described in more detail below:

GR - The Gross Revenue for the crop,
%Royalty Rate - The % royalty rate,
%Coverage - The % of crop area covered by new royalty,
%Compliance - The % producer compliance,
%Admin Cost- The % of royalty collected used for administrative costs,
%Investment Rate - The % of net royalty revenue reinvested.

The **%Coverage** will depend on whether CDC or SPG varieties are covered by the proposed royalty. We use the range of 30 % (low coverage) to 100 % (high coverage) for three new royalty scenarios. If CDC participates in the new system, coverage is going to be high.

The **%Compliance** depends on producer attitude and the effectiveness of the collection mechanism and therefore the range of compliance will differ by scenario. The **%Admin Cost** can be large for small revenue stream when compliance is costly to enforce. The range of administrative costs will differ depending on the collection mechanism.

In table 1, we reported the maximum potential royalty revenue, which is calculated as the Gross Revenue **GR** for the crop, multiplied by the **%Royalty Rate**/100. This maximum potential royalty income is reduced by the **%Coverage,** the **%Compliance** and the **%Admin Cost** to generate a *net royalty income*.

$$Net\ Royalty\ income = \frac{\text{GR}\times\%\ \text{RoyaltyRate}}{100} \times \frac{\%Coverage}{100} \times \frac{\%Compliance}{100} \times \frac{(100-\%Admin)}{100} \quad (1)$$

The royalty investment is in turn equal the net royalty income multiplied by the **%Investment Rate**/100.

$$Royalty\ investment = \frac{Net\ Royalty\ Income \times \%\text{Investment Ratement}}{100} \quad (2)$$

Combining these equations 1 and 2 into one equation the quantity of *royalty investment* is a product of five factors.

$$\$\ Royalty\ Investment = \frac{\text{GR}\times\%\ \text{RoyaltyRate}}{100} \times \frac{\%Coverage}{100} \times \frac{\%Complaince}{100} \times \frac{(100-\%Admin)}{100} \times \frac{\%Investment}{100} \quad (3)$$

These five factors will vary across Scenarios, B, C and D described above. To quantify how the range of these factors will affect each scenario.

Scenario B Trailing Royalty- Farm Saved Seed - UK

a) 30 % Coverage

If famers are uncooperative **%Compliance** could be 70%. For a small crop with enforcement issue **%Admin** could be 20%. In this case a 1% royalty **(% RoyaltyRate)** would only generate

$$Royalty\ Investment = \frac{GR\times 1}{100} \times \frac{30}{100} \times \frac{70}{100} \times \frac{(100-20)}{100} \times \frac{\%Invest}{100} \quad (3)$$

$$Royalty\ Investment = .168\% \times \text{GR} \times \frac{\%\text{Investment Rate}}{100} \quad (4)$$

$$Royalty\ Investment = .168\% \times \text{GR} \times \frac{30}{100} = .0504\% \times \text{GR} \quad (5)$$

With assumption as above 16.8% of potential royalty revenue would be collected. If we use 30% of royalty being reinvested, the reinvestment rate is .0504%. That would have a very limited impact.

$$Royalty\ Investment = .168\% \times \text{GR} \times \frac{90}{100} = .1512\% \times \text{GR} \quad (6)$$

If we use 90% of royalty being reinvested, the reinvestment rate is .1512%.

b) 100% coverage

%Compliance could be 70%**, %Admin** could be 20%.
In this case a 1% royalty rate would only generate

$$Royalty\ Investment = \frac{GR\times 1}{100} \times \frac{100}{100} \times \frac{70}{100} \times \frac{(100-20)}{100} \times \frac{\%Invest}{100} \quad (7)$$

$$Royalty\ Investment = .56\% \times \text{GR} \times \frac{\%\text{Investment Rate}}{100} \quad (8)$$

$$Royalty\ Investment = .56\% \times \text{GR} \times \frac{30}{100} = .168\% \times \text{GR} \quad (9)$$

Instead of assuming percentage of royalty rate (**% RoyaltyRate),** we calculate percentage of estimated royalty stream from Table 1. With assumption as above 56% of potential royalty revenue would be collected.

$$Royalty\ Investment = .56\% \times \text{GR} \times \frac{90}{100} = .504\% \times \text{GR} \tag{10}$$

If we use 90% of royalty being reinvested, the reinvestment rate is .504%.

Scenario C Uniform EPR France

a) the %Coverage could be 30%

As this system could be fairly easily enforced **%Compliance** could be 95%

Administrative cost of that system would be low as existing system for check off collection could be used to collect uniform EPR. Therefore assumed **%Admin** could be 2%.

In this case a 1% royalty **(% Royalty Rate)** would only generate

$$Royalty\ Investment = \frac{GR \times 1}{100} \times \frac{30}{100} \times \frac{95}{100} \times \frac{(100-2)}{100} \times \frac{\%Invest}{100} \tag{11}$$

$$Royalty\ Investment = .2793\% \times \text{GR} \times \frac{\%\text{Investment Rate}}{100} \tag{12}$$

$$Royalty\ Investment = .2793\% \times \text{GR} \times \frac{30}{100} = .0838\% \times \text{GR} \tag{13}$$

Instead of assuming percentage of royalty rate (**% RoyaltyRate),** we calculate percentage of estimated royalty stream from Table 1. With assumption as above 27.93% of potential royalty revenue would be collected.

If we use 30% of royalty being reinvested, the reinvestment rate is .0838%. That would have a very limited impact.

$$Royalty\ Investment = .2793\% \times \text{GR} \times \frac{90}{100} = .2514\% \times \text{GR} \tag{14}$$

If we use 90% of royalty being reinvested, the reinvestment rate is .2514%.

b) the %Coverage could be 100%

%Compliance could be 70%.
%Admin could be 2%.
In this case a 1% royalty **(% RoyaltyRate)** would only generate

$$Royalty\ Investment = \frac{GR \times 1}{100} \times \frac{100}{100} \times \frac{95}{100} \times \frac{(100-2)}{100} \times \frac{\%Invest}{100} \tag{15}$$

$$Royalty\ Investment = .931\% \times \text{GR} \times \frac{\%\text{Investment Rate}}{100} \tag{16}$$

$$Royalty\ Investment = .931\% \times \text{GR} \times \frac{30}{100} = .2793\% \times \text{GR} \tag{17}$$

Instead of assuming percentage of royalty rate (**% RoyaltyRate),** we calculate percentage of estimated royalty stream from Table 1. With assumption as above 93.1% of potential royalty revenue would be collected.

If we use 30% of royalty being reinvested, the reinvestment rate is .279%.

$$Royalty\ Investment = .931\% \times \text{GR} \times \frac{90}{100} = .838\% \times \text{GR} \tag{18}$$

If we use 90% of royalty being reinvested, the reinvestment rate is .838%.

Scenario D Competitive EPR Australia

a) the %Coverage could be **30%**

%Compliance could be 95%.
%Admin could be 10%.
In this case a 1% royalty **(% RoyaltyRate)** would only generate

$$Royalty\ Investment = \frac{GR \times 1}{100} \times \frac{30}{100} \times \frac{95}{100} \times \frac{(100-10)}{100} \times \frac{\%Invest}{100} \tag{19}$$

$$Royalty\ Investment = .2565\% \times \text{GR} \times \frac{\%\text{Investment Rate}}{100} \tag{20}$$

$$Royalty\ Investment = .2565\% \times \text{GR} \times \frac{30}{100} = .077\% \times \text{GR} \tag{21}$$

Instead of assuming percentage of royalty rate (**% RoyaltyRate),** we calculate percentage of estimated royalty stream from Table 1. With assumption as above 25.65% of potential royalty revenue would be collected.

If we use 30% of royalty being reinvested, the reinvestment rate is .077%.

$$Royalty\ Investment = .2565\% \times \text{GR} \times \frac{90}{100} = .2309\% \times \text{GR} \tag{22}$$

If we use 90% of royalty being reinvested, the reinvestment rate is .2309%.

b) the %Coverage could be 100%

%Compliance could be 95%.

%Admin could be 10%.
In this case a 1% royalty **(% Royalty Rate)** would only generate

$$Royalty\ Investment = \frac{GR \times 1}{100} \times \frac{100}{100} \times \frac{95}{100} \times \frac{(100-10)}{100} \times \frac{\%Invest}{100} \tag{23}$$

$$Royalty\ Investment = .855\% \times \text{GR} \times \frac{\%\text{Investment Rate}}{100} \tag{24}$$

$$Royalty\ Investment = .855\% \times \text{GR} \times \frac{30}{100} = .2565\% \times \text{GR} \tag{25}$$

Instead of assuming percentage of royalty rate (**% RoyaltyRate),** we calculate percentage of estimated royalty stream from Table 1. With assumption as above 85.5% of potential royalty revenue would be collected.

If we use 30% of royalty being reinvested, the reinvestment rate is .2565%.

$$Royalty\ Investment = .855\% \times \text{GR} \times \frac{90}{100} = .7695\% \times \text{GR} \tag{26}$$

If we use 90% of royalty being reinvested, the reinvestment rate is .7695%.

EPRs are very enforceable and its administrative cost is low. If the CDC adopts the system, the coverage will be high. The FSS model or the seed synergy version is going to be far less effective because of the individual reporting requirements. Table 2 reports royalty collected for Scenario B, C and D for high (100%) and low (30%) coverage. Reported royalty streams are adjusted by assumed compliance of 70 % for Scenario B and 95 % for Scenarios C and D and administrative cost of 20%, 2% and 10% for Scenarios B, C and D, respectively.

Table 2: Future Pulse Variety Royalty Generation by Pathway 2019-2058 conditional on assumptions for coverage, comply and administrative cost

Year	B low **Trailing Royalty** **(UK)** **%Cover 30** -16.8% of royalty in Table 1	B high **Trailing Royalty** **(UK)** **%Cover 100** -56% of royalty in Table 1	C low **Uniform EPR** **(CVO France)** **%Cover-30-** 27.93% of royalty in Table 1	C high **Uniform EPR** **(CVO France)** **%Cover 100-** 93.1% of royalty in Table 1	D low **Comp. EPR** **%Cover30 -**25.65 % of Royalty in Table 1 (Australia)	D high **Comp. EPR** **%Cover100-** 85.5% of Royalty in Table 1 (Australia)
	(C$Million/yr)					
2019	1.95	6.51	3.26	10.88	0.00	0.00
2020	1.95	6.51	3.26	10.88	0.00	0.00
2021	1.95	6.51	3.26	10.88	0.00	0.00
2022	1.95	6.51	3.26	10.88	0.00	0.00
2023	1.95	6.51	3.26	10.88	0.00	0.00
2024	1.95	6.51	3.26	10.88	0.00	0.00
2025	1.95	6.51	3.26	10.88	.39	1.29
2026	1.95	6.51	3.26	10.88	.78	2.59
2027	1.95	6.51	3.26	10.88	1.16	3.88
2028	1.95	6.51	3.26	10.88	1.55	5.17
2029	1.95	6.51	3.26	10.88	1.94	6.46
2030	1.95	6.51	3.26	10.88	2.33	7.76
2031	1.95	6.51	3.26	10.88	2.71	9.05
2032	1.95	6.51	3.26	10.88	3.10	10.34
2042	1.95	6.51	3.26	10.88	6.98	23.27
…						
2052	1.95	6.51	3.26	10.88	10.86	36.20
…						
2058	1.95	6.51	3.26	10.88	13.19	43.95

Source: Authors' estimates

3.2 Scenario Results

The benefits from greater investment in pulse breeding driven by enlarged royalty streams are estimated using a 13.5:1 benefit cost ratio over the 40-year life of investment. That benefit/cost ratio came from Gray and Scott (2003) which estimated of SPG benefits cost ratio for 1984-2008. It is conservative estimate as a later study by Gray et al. (2008) found the SPG benefit/cost ratio to be above 15.8:1 for period 1984-2012 and 20.2:1 for 1984-2024.

An essential variable in the analysis is the percentage of collected royalties that would be reinvested in pulse breeding. As pointed by Gray et al. (2017), public institutions tend to invest in breeding a high percentage of collected royalties. Private firms, on the other hand, have to fund other activities and pay dividends to their investors, and so reinvest a smaller percentage of collected royalties than public institutions. Since pulse crop breeding is dominated by AAFC and the Crop Development Centre at the University of Saskatchewan, in the best-case scenario, we assume that 90% of generated royalty revenue is invested in pulse crop breeding. If the breeding was done solely by private companies, the UK example suggests that about 30% of royalties would be invested in breeding. Canola and corn examples show that reinvestment rate could be even smaller, closer to 10% (Bolek, 2015).

The financial impacts of the alternative royalty pathways are reported in Table 3. The estimates are conducted with the assumptions of continued public involvement, a 90% royalty investment in breeding activities, 100 % coverage, 100% comply, 0 administrative cost, and no change in existing public and producer investment.

The NPV of pulse variety development differs by close to two billion dollars across the four scenarios. The status quo (Scenario A) shows that current investment in pulse breeding ($8.5 million/yr) delivers an NPV of benefits amounting to $1,467.4 million over a 40-year period. The UK like scenario with FSS royalties (Scenario B) increases the NPV of benefits to $3,252.8, million. The use of uniform EPR Scenario C (France CVO) increases the NPV of benefits to $3,261.2million. Scenario D, simulating the competitive EPR (Australia), increases the NPV of benefit to $2,677.6 million.

Table 3: Simulated Benefits and Costs of Alternative Royalty Pathways

		40 year	30 year	20 year
A: Status Quo				
PV benefits	C$million	1,616.9	1,167.6	541.3
PV costs	C$million	149.5	133.9	108.5
benefit cost ratio		10.82	8.72	4.99
NPV	C$million	1,467.4	1,033.7	432.7
B: Trailing Royalty - Farm-Saved Seed (UK)				
PV benefits	C$million	3,606.6	2,604.5	1,207.3
PV costs	C$million	353.8	316.9	256.9
benefit cost ratio		10.19	8.22	4.70
NPV	C$million	3,252.8	2,287.6	950.4
C: Uniform EPR (CVO France)				
PV benefits	C$million	3,616.1	2,611.4	1,210.5
PV costs	C$million	354.9	317.9	257.7
benefit cost ratio		10.19	8.21	4.70
NPV	C$million	3,261.2	2,293.5	952.8
D: Competitive EPR (Australia)				
PV benefits	C$million	3,070.5	1,714.1	585.9
PV costs	C$million	392.9	296.8	185.4
benefit cost ratio		7.81	5.77	3.16
NPV	C$million	2,677.6	1,417.2	400.5

Source: Authors' calculation see text

Long lags between investment and realizing benefits are reflected in the benefit/cost ratio, which for Scenarios A are 10.82, 8.72 and 4.99 for 40, 30- and 20-year time frame, respectively. For Scenarios B and C, benefit cost ratios are 10.19, 8.22 and 4.70 for the 40, 30- and 20-year time frame, respectively. The benefit/cost ratio for Scenario D (competitive EPR) is particularly impacted by a shorter time horizon because there is a phase when new varieties compete with free FSS of older varieties. For this scenario, the benefit/cost ratios are 7.81, 5.77 and 3.16 for the 40, 30- and 20-year horizons, respectively.

Scenario C generates the largest NPV and produces more benefits than Scenario D because the uniform EPR generates additional benefits faster than competitive EPR. Over a long period of time (longer than 40 years), the competitive EPR (Scenario D), could create the highest benefits while during the short term (20 years), they generate lower NPV than status quo.

Table 4 presents the results of a sensitivity analysis of coverage rates, compliance rates, percent administrative costs and royalty reinvestment rates. For each scenario, the present value (PV) of benefits, PV of costs, benefit/cost ratio. and NPV are reported. In the sensitivity analysis the coverage, i.e. the percent of production covered by the check off, ranges from 30% to 100%. and royalty reinvestment rate ranges from 30% to 90%. Administrative cost is assumed to be 20%, 2% and 10% for Scenarios B, C and D, respectively. Compliance rate is assumed to be 70% for Scenario B and 95% for Scenarios C and D.

As expected, including an administrative cost, a compliance rate and a coverage reduces the net present benefits for all scenarios, although net present benefits are still higher than in Status Quo except for Scenario D in a time frame of 20 years, which has lower NPV of benefits than Status Quo. Comparing low (30%) and high (100%) coverage shows, in 40-year time span, high coverage increases NPV in Scenario B from 1,544.5 to 1,724.3 $Million with a 30% reinvestment rate and from 1,767.3 to 2,467.0 $million with a 90% reinvestment rate. In Scenario C, the NPV of benefits increase from 1,596.3 to 1,986.9 $million when with a 30% reinvestment rate and from 1,968.7 to 3,138.2 $million 90% reinvestment rate. In Scenario D, net present benefits increase from 1,529.3 to 1,673.5 $million with a 30% reinvestment rate and from 1,777.8 to 2,502.1 $million 90% reinvestment rate. Scenario C with France uniform EPR rate continues to produce the highest NPV. Second best is Scenario D 90% reinvestment rate % and Scenario B with a 30% reinvestment rate.

Table 4: Simulated Benefits and Costs of Alternative Royalty Pathways contingent on Coverage, Compliance, Admin costs and Investment rate

				40 year	30 year	20 year
		B: Trailing Royalties (Farm-Saved Seed Royalty - UK)				
30% Coverage 70%Compliance 20%Admin	30% Investment Rate	PV benefits	C$million	1,728.3	1,248.1	578.6
		PV costs	C$million	183.8	164.6	133.5
		BC ratio		9.40	7.58	4.33
		NPV	C$million	1,544.5	1,083.4	445.1
	90% Investment Rate	PV benefits	C$million	1,951.1	1,409.0	653.1
		PV costs	C$million	183.8	164.6	133.5
		BC ratio		10.62	8.56	4.89
		NPV	C$million	1,767.3	1,244.3	519.7
100%Coverage=100 70%Compliance 20%Admin	30% Investment Rate	PV benefits	C$million	1,988.2	1,435.8	665.6
		PV costs	C$million	263.9	236.4	191.6
		BC ratio		7.53	6.07	3.47
		NPV	C$million	1,724.3	1,199.4	473.9
	90% Investment Rate	PV benefits	C$million	2,730.9	1,972.1	914.2
		PV costs	C$million	263.9	236.4	191.6
		BC ratio		10.35	8.34	4.77
		NPV	C$million	2,467.0	1,735.7	722.5
		C: Uniform EPR (CVO France)				
30% Coverage 95%Compliance 2%Admin	30% Investment Rate	PV benefits	C$million	1,803.1	1,302.1	603.6
		PV costs	C$million	206.8	185.3	150.2
		BC ratio		8.72	7.03	4.02
		NPV	C$million	1,596.3	1,116.8	453.4
	90% Investment Rate	PV benefits	C$million	2,175.5	1,571.0	728.3
		PV costs	C$million	206.8	185.3	150.2
		BC ratio		10.52	8.48	4.85
		NPV	C$million	1,968.7	1,385.8	578.1
100%Coverage 95%Compliance 2%Admin	30% Investment Rate	PV benefits	C$million	2,237.6	1,615.9	749.0
		PV costs	C$million	340.7	305.2	247.4
		BC ratio		6.57	5.29	3.03
		NPV	C$million	1,986.9	1,310.6	501.6
	90% Investment Rate	PV benefits	C$million	3,478.9	2.512.3	1,164.6
		PV costs	C$million	340.7	305.2	247.4
		BC ratio		10.21	8.23	4.71
		NPV	C$million	3,138.2	2,207.1	917.2

Continued…

Table 5 Continued: Simulated Benefits and Costs of Alternative Royalty Pathways contingent on Coverage and Investment Rate

				40 year	30 year	20 year
		D: Competitive EPR (Australia)				
30% Coverage 95%Compliance 10%Admin	30% Investment Rate	PV benefits	C$million	1,741.2	1,214.4	545.1
		PV costs	C$million	211.9	175.7	128.3
		BC ratio		8.22	6.91	4.25
		NPV	C$million	1,529.3	1,038.7	416.8
	90% Investment Rate	PV benefits	C$million	1,989.7	1,307.8	552.7
		PV costs	C$million	211.9	175.7	128.3
		BC ratio		9.39	7.44	4.31
		NPV	C$million	1,777.8	1,132.1	424.5
100% Coverage 95%Compliance 10%Admin	30% Investment Rate	PV benefits	C$million	2.031.2	1,323.4	554.0
		PV costs	C$million	357.6	273.2	174.2
		BC ratio		5.68	4.84	3.18
		NPV	C$million	1,673.5	1,050.2	379.7
	90% Investment Rate	PV benefits	C$million	2,859.8	1,634.8	579.4
		PV costs	C$million	357.6	273.2	174.2
		BC ratio		8.00	5.98	3.33
		NPV	C$million	2,502.1	1,361.6	405.2

Source: Authors calculations

The results of a sensitivity analysis to changes of the benefit/cost ratio and the rate of royalty reinvestment are reported in Table 5. In each comparison, a 40-year time horizon is used. Assumed coverage is 100%, compliance 100% and administrative cost is 0. The first column shows the difference in NPV from the status quo when the underlying benefit/cost ratio is reduced to 10:1. This could be the case if the marginal return to investment is much lower than the average past returns. The middle column shows the differences from the status quo if the underlying benefit cost ratio is 20:1 as in Gray et al. (2008) estimate of benefit/cost ratio for SPG investment in years 1984-2024. The last column shows difference from status quo if benefit/cost ratio was 40:1. This could be the case if additional resources enable the breeders to capture additional economies of scale and scope in their breeding programs. As expected, these results show the importance of return to breeding investments.

For each scenario, analysis has been done on what happens to the difference among scenarios if the rate of reinvestment of marginal royalty income decreased to 60% or 30%. This decrease would be likely if the public sector withdrawn from plant breeding and private companies come to dominate pulse breeding. The results show that the gains from the introduction of new royalties are largely reduced if the introduction of royalty system is accompanied by a substantial decrease in the rate of investment. If the reinvestment falls below 6.3 % in Scenarios B and C (for benefit cost ratio of 20:1), sector become worse off with new royalty than under status quo. In Scenario D, reinvestment has to be above 10.2 % for sector to be better off with new royalty than under status quo.

Table 6: Sensitivity to benefit cost ratio and Reinvestment Rate (40-year time frame)

	Assumed long run benefit cost ratio		
	10:1	**20:1**	**40:1**
B: Trailing Royalty - Farm-Saved Seed (UK)	Change in NPV from Status Quo ($Million)		
90% reinvestment rate	$1,269.2	$2,742.8	$5,689.9
60% reinvestment rate	$778.1	$1,760.4	$3,725.2
30% reinvestment rate	$286.9	$778.1	$1,760.4
Breakeven at 6.3% reinvestment rate		$0	
C: Uniform EPR (CVO France)	Change in NPV from Status Quo (Million)		
90% reinvestment rate	$1,276.1	$2,757.6	$5,720.7
60% reinvestment rate	$782.3	$1,769.9	$3,745.3
30% reinvestment rate	$288.4	$782.3	$1,769.9
Breakeven at 6.3% reinvestment rate		$0	
D: Competitive EPR (Australia)	Change in NPV from Status Quo (Million)		
90% reinvestment rate	$833.3	$1,910.1	$4,063.7
60% reinvestment rate	$474.4	$1,192.2	$2,627.9
30% reinvestment rate	$115.4	$474.4	$1,192.2
Breakeven at 10.2% reinvestment rate		$0	

Source: Authors' Calculation as described in the text

4.0 Summary and Conclusion

Canada has very successful pulse crops breeding program that is currently funded by producer checkoffs and the public sector. Production volume and area used by pulse crops in Canada has increased significantly in last three decades. The yield trends of dry peas and lentils have positive slopes. All those indicate the pulse breeding program is doing well in Canada. However, the demands for additional growth of breeding investment is likely to persist, raising the question of whether the current check-off levy funding system is able to generate sufficient research funds post-2020. Serfas and Gray (2018) found if the pulse breeding sector maintain the status quo with the check-off levy system, the industry will forego significant additional long-term benefits. To fully benefit from the expansion in pulses markets, more investment is needed.

The Growth Act 2015 made Canada compliant with the UPOV 91 convention and introduced to Canadian legislation stronger protection of breeders' rights that opens opportunities to impose royalties on new varieties and enable the increase of future investments in pulse breeding.

In this paper, to analyze consequences of new legislation for pulse sector, we adopted the approach used by Gray et al., (2017) in their study *Intellectual Property Rights and Canadian Wheat Breeding for the 21st Century.* To design possible scenarios of royalty systems, we reviewed pulse breeding systems in countries which have been compliant with the UPOV 91 convention for some time. Review of UK, France and Australian systems for pulse breeding as well as Canadian status quo, enabled creation of four possible scenarios for Canada. Scenario A involves Canada sticking with status quo of producer check-off levies. Scenario B entails Canada adopting a UK styled system with royalties on FSS. Scenario C involves Canada introducing something like France's uniform EPR. Scenario D would involve introducing competitive EPR rates such as in Australia.

The simulations of royalty streams and benefit/cost analysis suggest that the creation of an effective royalty system could have a multi-billion-dollar benefits for the pulse industry. The status quo (Scenario A) results in the smallest benefits among considered options. The most beneficial strategy (Scenario C) would involve adopting a system like in France with uniform

EPR rates. Next best would be adopting FSS royalties as in the UK, (Scenario B). Scenario D, with the competitive EPR rates like in Australia, has a significantly lower NPV, albeit, still above the status quo. The Australian system is characterized by delay in revenue caused by fact new varieties with the EPR rates attached have to compete with free varieties present in the market. However, despite that delay, competitive EPR, after 15 years, generated more revenues than either of the scenarios. That suggests in long run, Scenario D will produce the highest NPV. At current size of production, NPV from competitive EPR in Scenario D will be lower than under Scenarios B and C in 20, 30 as well as 40 years.

While pulse crops are an important source of plant protein and have the environmental advantage of nitrogen fixation, the development of higher yielding more disease resistant varieties is needed to expand production beyond current limits.

Conclusion

Canada has been, by far, the most successful country when it comes to developing a globally competitive pea and lentil industry. Past success in breeding and other complementary research has allowed Canada to become a leading global producer dominating many export markets. While these impressive results have creating billions of dollars in benefits for Canadian producers, the demand for pulse research is likely to continue to increase.

The 2015 Agricultural Growth Act expands plant breeder right's in Canada to be consistent with the UPOV 1991 convention. In other countries, notably UK, France and Australia, UPOV91 has enabled the collection of royalties from all producers growing protected varieties. Notably, their legislation also includes fines and other legal mechanisms beyond the Plant Breeders Rights to increase the effectiveness of royalty collection. In these countries, the expanded royalty stream has enabled private firms to expand breeding efforts.

The 2015 Agricultural Growth Act Canada provides the authority to adopt similar systems to enhance royalty income but the approach is unresolved.

Our analysis shows that if a significant portion of these larger royalty streams are reinvested to increase pulse research and breeding, it would create several billion dollars in additional benefits for the Canadian pulse sector. However, we also note that if the reinvestment rate falls, so does the return. At the extreme, if reinvestment falls below 6.3% in Scenario B and C and 10.2% in Scenario D, it could leave the sector worse off. As such, any plan to implement any new royalty must be made with caution and include mechanisms to ensure high net rates of reinvestment. One approach would be to secure mechanisms and long-term institutional arrangements to ensure that existing producer and public investment is not diminished. Otherwise, if the new royalty structure encourages more private breeding, lower reinvestment rates and returns may ensue.

For the reasons stated above, the future structure of the research and breeding institution is vitally important. Who will do the research? How will it be funded. What partnerships will exist? Where with the royalty income flow? How will the royalties be used? Are there unexploited economies of scale and scope in pulse breeding? The answers to these (and probably other) questions will determine which system is optimal. The plans of existing producer organizations including, SPG, MPSG, APG, GFO, and existing public institutions including AAFC, CDC, and the private sector will shape options that are available and the future of the sector.

Finally, with all the analysis of options, it is very important to understand producer perceptions and attitudes. Collectively, producers have the most at stake economically. Producer voices need to be heard in the political arenas where decisions will be made. Ultimately, producer attitudes also play a key role in compliance, enforceability and collection of royalties. Farmers who see themselves as partners and beneficiaries of the system will be willing participants; farmers alienated from the benefits will work at cross purposes to the intent. Well-grounded policy will determine the impact of the policy choices the industry faces.

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