MINI-REVIEW

Historical review of faba bean improvement in western Canada

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Abstract

Faba bean (Vicia faba L.) was considered a minor crop in the Canadian prairies until recently, but its potential for cultivation is increasing due to its positive environmental impact and economic value. This review provides a historical summary of faba bean improvement in western Canada. Although traditional breeding methods have proved useful, in the last decade, faba bean improvement has benefited from advances in genetics, biochemistry and molecular breeding tools. The overall breeding goal is to develop high yielding germplasm with improved agronomic characteristics that will be of economic value to the emerging faba bean sectors, including the plant protein industry. To maximize value and acceptance by producers, processors and the food industry as a source of protein and dietary fibre, future faba bean varieties need to be high-yielding, have diverse seed size classes, disease resistance, genetically low vicine–convicine concentration, and have wider adaptation to different agro-ecological zones of Canada. The experiences over the last 40 years of faba bean improvement in western Canada may be useful to other breeding programmes globally located in regions with similar agroecology. In the past 10–15 years, faba bean genetic development in Canada has benefited greatly from research and development interactions with most of the faba bean research programmes in northern Europe.

KEYWORDS
disease resistance, legume improvement, plant breeding, quality traits, Vicia faba

1 INTRODUCTION

Faba bean seeds are a generous source of protein, starch, dietary fibre, minerals and vitamins (Duc et al., 1999; Khazaei & Vandenberg, 2020; Marshall et al., 2021; Warsame et al., 2020) and are widely grown for food, feed and green manure globally (Duc et al., 2015). Seed protein content varies from 24% to 35% of seed dry matter; the protein is very rich in lysine and arginine and poor in sulphur-containing amino acids (reviewed by Khazaei, Subedi, et al., 2019). Faba bean has very efficient nitrogen (N) fixation, providing about 90% of the plant's N needs (Hauggaard-Nielsen et al., 2009), probably the highest value among grain legumes. About half of the crop's N content is left in the field for the next crop (reviewed by Watson et al., 2017). In a study on pulses grown in the Western Canada, faba bean had the highest levels of N fixation (88% of N derived from the atmosphere) (Walley et al., 2007). The percentage of N derived from fixation is also strongly affected by the level of N available in the soil, growing conditions, cultivar and N-fixing bacteria strain of Rhizobium (Dean & Clark, 1980). The low reliance on nitrogen chemical fertilizer inputs in faba bean production reduces greenhouse gas emissions, providing excellent ecological services. Faba bean has a bright future as a protein crop that provides additional legume crop rotation benefits for the prairie provinces of Canada. Its production is poised for rapid growth because of demand for plant-based protein...
products. Faba bean produces plant-based protein that is non-genetically modified and nonallergenic (unlike soybean) (Vatansever et al., 2020). Faba bean is well adapted to wet and cold agricultural environments (Link et al., 2010). This allows further expansion of the potential pulse production areas of western Canada, which would expand the benefits of including an annual legume in the production system. Faba bean is relatively unaffected by Aphanomyces euteiches Drechs., the causal organism of aphanomyces root rot (ARR) of pea (Pisum sativum L.) and lentil (Lens culinaris Medik.) crops (Moussart et al., 2008), nor is it affected by Colletotrichum lentis Damm, the causal organism for anthracnose of lentil. It has better lodging tolerance and harvestability than other pulse crops. Commercial production of faba bean in Canada started in 1972 when greater crop diversity was sought (McVicar et al., 2005), and by 1980, 23,000 ha was devoted to the crop (Sinkard & Buchan, 1980), but production area decreased to about half by the 1990s. In 2020, its cultivated area was near 36,000 ha (Statistics Canada, 2020). This review provides a brief historical summary of faba bean improvement in western Canada as the dominant producing region in North America, the gaps in current knowledge, and how this can be used to breed new faba bean cultivars for the region.

2 | HISTORICAL BACKGROUND OF FABA BEAN IMPROVEMENT IN CANADA

Interest in faba bean in western Canada began with the introduction of European germplasm in the late 1960s. In the 1970s, faba bean breeding was established at the University of Manitoba (UManitoba) and University of Saskatchewan (USask) but both programmes became dormant in the 1990s. Fifteen European cultivars were tested in Manitoba and Saskatchewan during 1970–1971 (Evans et al., 1972). More accessions were introduced and tested during the period 1971–1973 at over 20 locations in western Canada and four European cultivars (Ackerperle, Diana, Erfordia and Herz Freya) were licenced. Due to the short growing seasons of Canadian prairies, the spring-type cultivars from the continental European zone (e.g., Germany and Austria) were initially the best adapted germplasm. Beginning in the early 2000s, Limagrain Europe introduced a few advanced varieties (e.g., Snowbird, Rodeo and Imposa) adapted to the Canadian prairie climate. In 2002, the faba bean programme at the Crop Development Centre (CDC), USask was expanded to include a specific focus on developing a new germplasm base combining small seed size (1000-seed weight of 300–350 g) with reduced concentrations of the anti-nutritional factors vicine–convicine (v-c) and condensed tannins. Small-seeded, round-shaped faba beans reduce risk and seeding costs without sacrificing yield potential. At this time, 1500 faba bean accessions were evaluated at two locations in Saskatoon. The sources of the small seed phenotype were primarily from South Asia (e.g., Afghanistan and Bangladesh), and the sources of white flower (low tannin, zt1 gene) were mainly European spring cultivars (Duc et al., 1999).

The list of faba bean varieties released in western Canada is shown in Table 1. Canadian faba bean breeding was initially based on selections from introduced European germplasm. Aladin and Outlook, the first two varieties officially released in Canada, had Czechoslovakian and British origin, respectively. Two landraces from Afghanistan (PI 221517 and PI 222129) were also used in the pedigree of early released varieties mainly due to their reduced seed size. The cultivars released later were based on single crosses undertaken in Canada. However, recent progress has seen the release of varieties such as 219-16 (low tannin), 1142-16 and 1139-11 (both with low tannin and v-c, known as FEVITA® type; Duc et al., 2004), which resulted from multiple crosses to combine yield potential, small seed size, food quality and agronomic performance.

Over the past decade, DL Seeds (http://www.dlseeds.ca/pulses.shtml) has been evaluating, selecting and releasing lines from NPZ (Norddeutsche Pflanzenzücht, Holtsee, Germany) that are adapted to the western Canadian climate zones. These include Vertigo, Fabelle (low v-c), Taifun (low tannin), Tabasco (low tannin), DL Rico (FEVITA type) and DL Tesoro (low tannin). Breeding strategies used by NPZ are based on pedigree selection, and “synthetic” cultivars where three or more founder lines are allowed to intercross for a limited number of generations as the seed supply is increased. Breeding of synthetic cultivars is an alternative to hybrid breeding and is the most widely used breeding strategy for faba bean breeding due to its elevated level of cross-fertilization (Link et al., 1994). Heterosis and inbreeding depression expressed by faba beans favour the use of synthetic and population breeding lines over pure lines (Bond, 1982). Most faba bean cultivars bred in western Canada (Table 1) have been developed by recurrent/mass selection or pedigree selection. The current USask breeding programme is based on the F2-derived family breeding method that has been successfully used in lentil and pea, the major pulse crops of western Canada.

Table 1 also shows the broad diversity in origin of faba bean germplasm used in the pedigree of Canadian breeding materials compared with those from Australia that are mainly based on Mediterranean germplasm. The initial Australian faba bean breeding programme dominantly relied on the introduction of germplasm from the Mediterranean Basin provided by International Center for Agricultural Research in Dry Areas (ICARDA) and other sources. Like Canada, adaptation, yield stability, disease resistance and improved quality traits were the major breeding goals in Australia and the basis of germplasm introduction. In both countries, disease resistance and early flowering were key components of adaptation that played critical roles in increase of grower acceptance. In Australia, the faba bean industry started with the release of cv. Fiord in 1980, which was a selection from Ac59 from the island of Naxos, Greece. Fiesta was one of the early cultivars in the country released in 1997, a selection from BPL 1196 originating from Spain. In the early 2000s, Nura was the first Australian cultivar developed from a controlled crossing (Icarus × Ascot). Recently, cultivars were released with improved yield and disease resistance and abiotic stresses. In 2006, faba bean production was 183,000 ha (ABARE, 2006) and has slightly increased to 196,000 ha in 2019 (FAOSTAT, 2019). The majority of faba bean
| Cultivar | Year released | Pedigree | 1000-seed weight (g) | Description | Breeding institute | Reference |
|----------|---------------|----------|----------------------|-------------|-------------------|-----------|
| UMFB-9   | 1977          | Selection from a European line | 346         | High productivity. It was supported for licensing in 1977 (the first attempt for releasing a faba bean variety in Canada). | UManitoba | Furgal and Evans (1980) |
| Aladin   | 1981          | Single plant selection from cv. Stagania (Czechoslovakia) | 437         | Stagania is registered as ILB 626 (IG 11820). | UManitoba | McVetty et al. (1981) |
| Outlook  | 1981          | Single plant selection from cv. Tarvin (UK) | 368         | Tarvin is an old British late-maturing high-yielding spring bean with long straw from Gartons Ltd., UK. | USask | Rowland et al. (1982) |
| Pegasus  | 1984          | Ackerperle (Germany) × PI 221517 (Afghanistan) | 376         | Ackerperle also known as Francks Ackerperle. Breeder company was Pflanzenzucht Oberlimburg, Dr. Peter Franck. The original source of PI 221517 is Lai, Panjab, 66 miles west of Kabul. It has small round seeds. | UManitoba | McVetty et al. (1985) |
| Encore   | 1985          | Single plant selection from PI 222129 (Afghanistan) | 368         | Seeds of PI 222129 were obtained from a local market in Kabul. | USask | Rowland et al. (1986) |
| Orion    | 1987          | Diana (Germany) × HBNYT-73-I-37 (UManitoba) | 350         | HBNYT-73-I-37 was an early-maturing, black-seeded line from UManitoba. | Agriculture Canada | Berkenkamp and Meeres (1988) |
| CDC Blitz| 1994          | Chinese Broad Bean × Outlook | 410         | Chinese broad bean is a large-seeded landrace from China. | USask | https://bit.ly/34mIyxw |
| CDC Fatima| 1994       | Selection from Chinese Broad Bean | 520–600       | CDC Fatima is an established cultivar developed for the prairie provinces of Canada. | USask | Graf and Rowland (1987) |
| CDC Snowdrop | 2011 | Snowbird (Netherlands) × Ascot (Australia) | 330         | Low tannin (zt1). Snowbird pedigree: Alfred × 8103. Alfred pedigree: Minica (Netherlands) × Horse bean released in the Netherlands. Ascot is a selection from cv. Fiord from Australia. Original source of germplasm is Greece. | USask | https://bit.ly/3gVuU9Q |
| CDC SSNS-1| 2013        | Bulk selection from Ackerperle | 330–350       | Francks Ackerperle (see above) | USask | https://bit.ly/2KuBJDb |
| CDC Malik (FB 9-4) | 2013 | MO-1 (Egypt) × Earlibird (Netherlands) | 680         | MO-1 was an Egyptian landrace provided by Mohammad Zakaria. Earlibird was bred at Innoseeds B.V., the Netherlands. | USask | |
| 247-13   | 2014          | Snowbird × (Puebla × Taboar) | 620         | Puebla is an accession from Mexico. Taboar was developed by Globe Seeds, the Netherlands. Taboar pedigree: Rowena × Herz Freya | USask | https://bit.ly/37rqiQc |
| Taifun   | 2014          | A synthetic line derived from NPZ3-7410, NPZ2-7540, NPZ2-7560, NPZ2-7510, and NPZ3-7401 | 485         | Low tannin (zt1), with the exception of Taifun, all the other lines from NPZ Germany were selected in Morden, Canada and then trialled using the coop system. | NPZ | https://bit.ly/2XCmdZf |
| 219-16   | 2014          | (IPK296-78 × Snowbird) × (IPK251-78 × Snowbird) | 356         | Low tannin (zt1) | USask | https://bit.ly/3gUHLu |

(Continues)
| Cultivar        | Year released | Pedigree                                      | 1000-seed weight (g) | Description                                                                 | Breeding institute | Reference                        |
|-----------------|---------------|-----------------------------------------------|----------------------|-----------------------------------------------------------------------------|--------------------|-----------------------------------|
| 186s-11         | 2014          | Reina Blanca (Spain) × Puebla                 | 880                  | Reina Blanca is an early vegetable type large-seeded faba bean from Semillas Fitó Global, Spain. | USask              | https://bit.ly/3gU6AoR            |
| Fabelle         | 2015          | Lady (France) × Marcel (Denmark)              | 527                  | Low v-c                                                                     | NPZ                | https://bit.ly/2LKNTbR            |
| Vertigo         | 2015          | A synthetic line derived from NPZ4-7610, NPZ4-7640, NPZ6-7480 and NPZ5-7820 | 565                  | It was developed by NPZ Germany using internal breeding materials.          | NPZ                | https://bit.ly/3ick6Vx            |
| DL Rico         | 2018          | (NPZ0.27410 × P 14119.9) × (Espresso × (Gloria × Divine)) | 588                  | FEVITA® type. Bred and selected in NPZ Germany. Parental lines are from European and NPZ breeding lines. Gloria is white-flowered (zt1) from Saatzucht Gleisdorf, Austria. | NPZ-DL seeds      | https://bit.ly/35zEtXD            |
| DL Tesoro       | 2018          | ([Gloria × Divine] × NPZ06.7101) × (Mélodie)  | 512                  | Low tannin (zt1). Mélodie and Divine are low v-c from INRA, France.         | NPZ-DL seeds      | https://bit.ly/38BzUxW            |
| 1142-16         | 2019          | (405-6 × AO1155) × (AO1155 × 469-1)            | 350                  | FEVITA type. 405-6 and 469-1 are U of S experimental lines. AO1155 was developed by INRA, France and was the source of the low v-c and low tannin (zt1). | USask              | https://bit.ly/38ba0Qa            |
| 1139-11         | 2019          | (224-34 × AO1155) × (AO1155 × 224-56)          | 351                  | FEVITA type. Breeding lines 224-34 and 224-56 are selected from cross IPK251/81 × Snowbird. | USask              | https://bit.ly/38fFBQy            |

Abbreviations: CDC, Crop Development Centre; INRA, Institut National de la Recherche Agronomique; NPZ, Norddeutsche Pflanzenzücht; UManitoba, University of Manitoba; USask, University of Saskatchewan.

*FEVITA® has been given to improved-quality faba beans in which seeds have both reduced tannin content and vicine-convicine, v-c (Duc et al., 2004).
production in Australia is targeted for the traditional food markets in the Middle East, particularly Egypt.

3 | FABA BEAN GENETIC RESOURCES IN CANADA

Of about 43,000 faba bean accessions maintained in genebanks worldwide (Duc et al., 2015), Plant Genetic Resources of Canada at Agriculture and Agri-Food Canada Saskatoon hosts only 84 accessions. This is not surprising as to date the crop is not yet extensively cultivated in Canada. The Faculty of Agriculture, UManitoba deposited 278 faba bean research lines with the ICARDA genetic resources system (https://www.genesys-pgr.org/wiews/CAN086) during 1974–1983. The breeding materials developed at UManitoba nearly 40 years ago may have limited viability or may have already been discarded. USask currently keeps a collection of about 1000 exotic faba bean accessions along with several research lines and segregating populations that were developed for genetic studies of various agronomic and biochemical traits.

4 | TARGETS FOR BREEDING

4.1 | Anti-nutritional factors

Besides the great importance of faba bean for human consumption and livestock feed due to its high protein quantity and quality, dietary fibre and nutritional value (Crépon et al., 2010), its seeds contain v-c, one of the main factors limiting faba bean cultivation and usage. Consumption of v-c is harmful for human carriers of a widespread genetic defect (glucose-6-phosphate dehydrogenase deficiency, G6PD) and is also a concern for monogastric animal and poultry production (see review by Khazaei, Purves, et al., 2019). One of the most immediate breeding goals in Canada was to phase out faba beans with high v-c content. This work began with the introduction of the crop to the country at UManitoba in the 1980s (see Gardiner et al., 1982; Marquardt & Fröhlich, 1981). This process has been accelerated at USask by the improvement of high-throughput biochemical phenotyping methods (e.g., Purves et al., 2018) combined with the development of a robust and low-cost molecular marker for the low v-c gene (v-c; Khazaei et al., 2017). The entire USask faba bean programme will be converted to low v-c status in the near future. High v-c parents in the crossing programme will still be used, if needed, but only in initial crosses. In this case, F1 plants will be crossed only to low v-c parents, and the resulting F2s will be grown out only if crossed seeds are homozygous for the low v-c allele based on the molecular marker test. Maintenance of low v-c status throughout the faba bean breeding and production system requires deliberate and active management over time and space to ensure isolation from sources of high v-c contamination by pollinators, for example, at off station breeding nurseries.

In faba bean, white flower colour, together with a low seed coat tannin, is determined by either one of two complementary genes (zt1 and zt2). Seed coat tannins reduce protein digestibility and add colour to seed coat fibre products. Although tannins are entirely in the seed coat and can easily be removed mechanically, dehulling brings an additional cost. Reliable molecular markers for both genes have been developed (Gutierrez & Torres, 2019; Zanotto et al., 2020). CDC Snowdrop was the first small-seeded zero tannin (zt1) cultivar released in Canada. Although all the Canadian-bred low tannin faba beans carry zt1 (Table 1), the zt2 gene may have been used in the background of some prebreeding materials. Cross pollination of the two low tannin sources leads to the loss of expression of the low tannin trait in the progeny. Most of the recent breeding materials released by CDC are FEVITA type that combine low v-c and low tannin zt1 (Table 1). The risk of contamination from sources of the zt2 allele are much lower than the risk posed by contamination with high v-c because the zt2 is not widely used in breeding programmes. Some earlier studies showed the poor emergence of low tannin cultivars from cold soil which was associated with testa cracking (e.g., Kantar et al., 1996). A recent study reported the frost susceptibility of low tannin faba beans (Henriquez et al., 2017). Nevertheless, a highly winter hardy low tannin (zt1) faba bean (cv. Gladice) was released by Agri-Obtentions, France (Link et al., 2010). This controversy needs to be confirmed in a larger germplasm base with wider genetic diversity to uncover the role of tannins and their reputed association with physiological basis of frost tolerance.

4.2 | Disease resistance

Since the introduction of the crop in western Canada, chocolate spot (CS) caused by Botrytis fabae Sard. was the major biotic stress affecting faba bean productivity (Furgal & Evans, 1980; Sumar et al., 1981). The disease can reduce yield by 71% (Sahile et al., 2008). Several fungicides are registered for control of CS in faba bean crops, but they are effective only for suppression and not control. The current extent of CS damage and genetic diversity of its pathogens are not well defined in Canada, so the development and release of cultivars with superior resistance remains an active breeding goal. One of the UManitoba research lines that was deposited to the ICARDA germplasm collection in 1974 (ILB 611 or IG 11805) was shown to be very resistant to CS (Maalouf et al., 2016). Genetic resistance breeding and genomic approaches to improve resistance to CS is in progress at USask using germplasm derived from ILB 938 (IG 12132), an accession with proven resistance to CS (Khazaei et al., 2018). The genomic tools required as part of this effort are provided by the University of Reading, UK.

Faba bean rust, Uromyces viciae-fabae (Pers), has also been reported occasionally (e.g., McKenzie & Morrall, 1975). A high degree of pathogen variability was reported (Conner & Bernier, 1982), and several sources of resistance were found via screening trials in Manitoba (Rashid & Bernier, 1991). Considerable attention was given to this disease compared with CS; however, faba bean rust is much more common throughout the Mediterranean regions (warm and humid conditions, >20°C and 80% relative humidity) and is relatively less harmful for faba beans grown in the north temperate zones (Stoddard et al., 2010).
Ascochyta blight (Ascochyta fabae Speg.) was reported to be the most destructive faba bean disease in Manitoba but not in Alberta and Saskatchewan in the 1970s. However, it has potential to become a threat for faba bean production in western Canada. Several sources of resistance along with reliable molecular markers have been developed in the Mediterranean regions of Europe and Australia (reviewed in Khazaei et al., 2021), where the disease is widespread. These tools can be adapted by Canadian breeding programmes.

One of the most important characteristics of faba bean is its high level of resistance to the soil-borne pathogen ARR (Moussart et al., 2008) which is now widespread in the Canadian prairies and is now a severe threat to future pea and lentil production. This makes faba bean a great candidate for inclusion in extended crop rotations that include pea and lentil, the major pulse crops in western Canada. To date, there are no easily accessible good sources of ARR resistance in pea and lentil, and extending rotations with faba bean will likely ameliorate the problem to some extent, while maintaining an excellent supply of plant-based protein.

4.3 Yield and abiotic stresses

Faba bean has the highest potential yield of any food legume (Cernay et al., 2015). The average faba bean yield in western Canada is about 3 t ha⁻¹, about 100% and 25% higher than lentil and pea, respectively (unpublished data). Faba bean has beneficial associations with two groups of organisms—nitrogen-fixing bacteria and pollinators. The main nitrogen-fixing organism is Rhizobium leguminosarum biovar. viciae which has positive impact on yield (Elshiekh & Elzidany, 1997). The main pollinators of faba bean are honey bee (Apis mellifera) and bumblebees (Bombus spp.) that can enhance yield (Stoddard, 1986; Stoddard & Bond, 1987), particularly under abiotic stress conditions (Bishop et al., 2016). Among pulses grown in western Canada, faba bean is the most drought susceptible (Mukhtar et al., 2020). Development of commercially acceptable and adapted faba bean germplasm and breeding lines with improved drought adaptation for use in the dry/nonirrigated region of western Canada is needed. Maximizing the genetic potential for drought adaptation is a key feature of the future genetic base for faba bean in western Canada and a major long-term breeding goal. Both conventional and molecular breeding tools are needed to accelerate the development and release of improved drought-adapted faba bean cultivars with relatively high and stable yield. Recently, we have developed a speed breeding protocol for faba bean (Mobini et al., 2020) as a tool for developing diverse germplasm and improved varieties in a shorter time span.

4.4 Utilization of faba bean—Past, present and future

Extensive genetic variability of seed composition of faba bean exists, which opens the possibility of breeding for various end-use quality traits (Crépon et al., 2010). Currently, most Canadian faba bean production is targeted to the animal feed protein industry locally and to the food market globally. For example, CDC Malik is one of few cultivars that is produced in large volumes that is suitable (large-seeded, normal-tannin) for the Middle East export market. Snowbird, which is a medium-sized, low tannin faba bean cultivar, dominates production with over 50% of production in Saskatchewan (https://www.scic.ca/resources/smp/smp-data/). Faba bean seeds typically have 30% protein (dry matter basis) (Warsame et al., 2020), which can be made into protein concentrates (more than 60%) through dry milling and air classification or into isolates of more than 90% protein through wet processing (Gueguen, 1983). The seed coat fraction is potentially valuable as a dietary fibre concentrate in the pet food industry, which now uses pea seed coat fibre. Therefore, the protein and fibre, the most valuable fractions, make up almost 45%–50% of the seed, a total that is about 15% higher than in pea (Heuzé et al., 2018). To maximize value and acceptance by processors and the food industry as a source of protein and dietary fibre, the future faba bean varieties should ideally be small-seeded to reduce seeding costs, and have the characteristics of low tannin and low v-c to be acceptable in the food market. The damage caused by lygus bugs (Lygus spp.) and seed weevils (Bruchus spp.) is detrimental to faba bean seed quality, but genetic resistance to these major pests is not fully understood (Carrillo-Perdomo et al., 2019; Kaur et al., 2018).

5 Conclusions and perspectives

The focus of this contribution is progress in faba bean breeding in western Canada over the past four decades, but the experiences may be useful for any other regions in the world where the crop is under development. One of the main breeding challenges is partial allogamy of this crop. In the open field, seed production purity suffers by the effects of cross-pollination, which adds technical constraints to prevention of uncontrolled outcrossing by insects. However, a dedicated transition to a germplasm base that is genetically uniform for the vc allele and the zt1 allele could be worthy goals to accelerate expansion of the emerging faba bean food and ingredient processing industry. There is an urgent need to expand the role of faba bean in western Canada for economic and environmental reasons. Expansion of the use of early maturing, small-seeded, white-flowered, low v-c faba bean varieties will help expand plant-based protein production at lower costs, while extending crop rotations for pea and lentil production. These new varieties must be able to tolerate early sowing and drought and should ideally have round seed shape to accommodate the uniform seed singulation systems designed for a new generation of zero tillage planting systems. This will require additional coordinated research investment in both plant breeding and agronomy to help maximize production potential and to reduce production risk for the plant-based protein industry.

We expect that faba bean cultivation will expand rapidly over the next 5 years in response to the demand for plant-based protein in the rapidly growing plant-based food and ingredients sector. We also can expect that, based on trends experienced with other pulses, the
production system in western Canada will support five to 10 improved faba bean varieties, especially if improvements in agronomy, genetics and crop rotation strategies result in a significant expansion of faba bean production to the southern soil zones. In the case of faba beans, an additional consideration is that the crop is not affected by the ARR (unlike lentil and pea); the crop can be sown very early in the spring, and the nitrogen fixation potential is much higher than other grain legumes. There is potential for faba bean to reach 400,000 ha within 10 years, and the majority of this production will be for fractionation to supply ingredient markets. We expect very little growth in the supply of faba beans of traditional market classes for traditional markets.

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CONFLICT OF INTEREST
The authors have no conflict of interest.

AUTHOR CONTRIBUTIONS
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ETHICS STATEMENT
This manuscript does not contain any studies with human or animal subjects.

DATA AVAILABILITY STATEMENT
Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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