Bean breeding and at the University of Guelph: Past and present

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Emily Warrender June 19, 2025

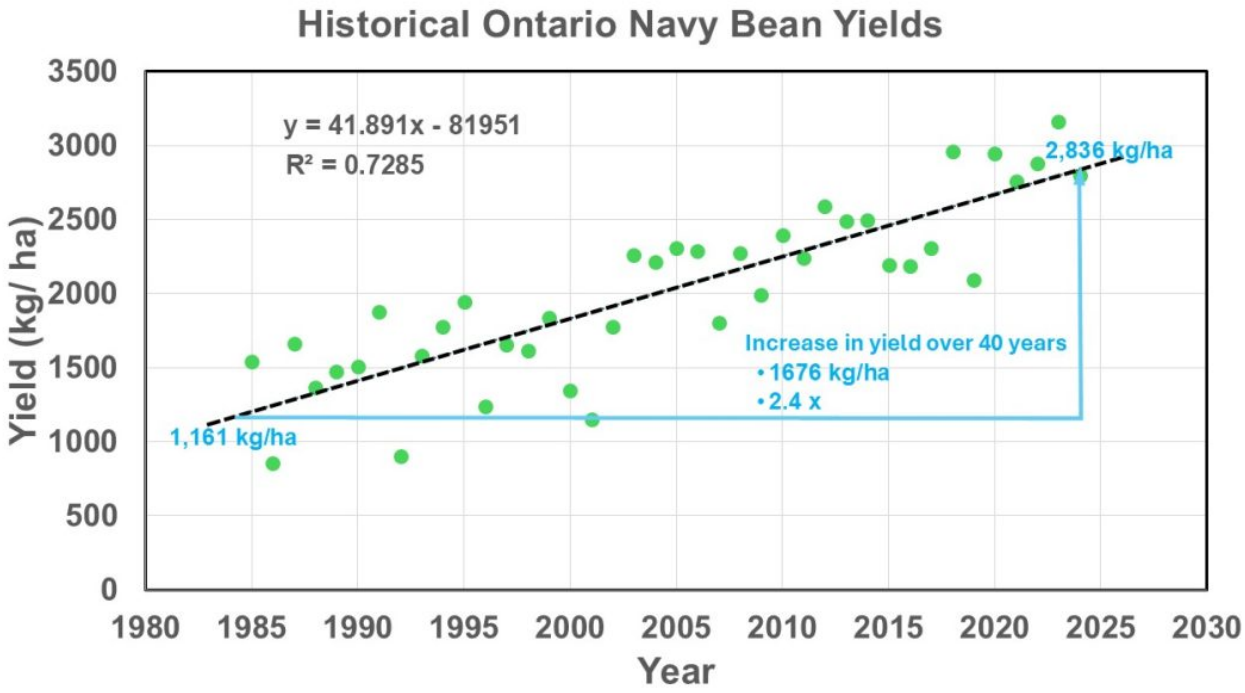

Figure 1. Historical Ontario white navy bean yields.

Examine bean breeding at the University of Guelph, both past and present, conducted by its Department of Plant Agriculture

Bean production in Ontario

The common dry bean (Phaseolus vulgaris) is a staple for >300 million people. Canadian bean production is worth >300M USD annually. Beans are highly nutritious, they contain nutraceuticals and have positive environmental effects through their ability to fix atmospheric nitrogen (Hesami and Yoosefzadeh-Najafabadi, 2025). Crop breeding and improved agronomic practices have resulted in 3.8 % per year yield increases in Ontario (Figure 1).

Bean breeding at Guelph

The University of Guelph Bean Breeding Program, previously led by K. Peter Pauls (2003-2024) and currently led by Mohsen Yoosefzadeh-Najafabadi (since 2024) is co-ordinated by technician Lyndsay Schram. It utilizes a population breeding strategy based on recurrent selection to improve the traits of various bean market classes and Adzuki (Vigna angularis) beans.

The breeding strategies are based on dynamic germplasm pools, to which new genetic diversity is introduced during each breeding cycle and the frequency of favourable alleles is gradually increased through multiple cycles of phenotypic and genotypic selection to result in improved varieties (Figure 2).

Each year, the bean breeding program makes >200 crosses, advances 800 F2-F5 families and 3,500 rows from single plants, conducts 14 preliminary and advanced yield trials and tests selections in the Ontario Pulse Crop committee (OPCC) Registration and Performance Trials to identify and develop new registered bean varieties.

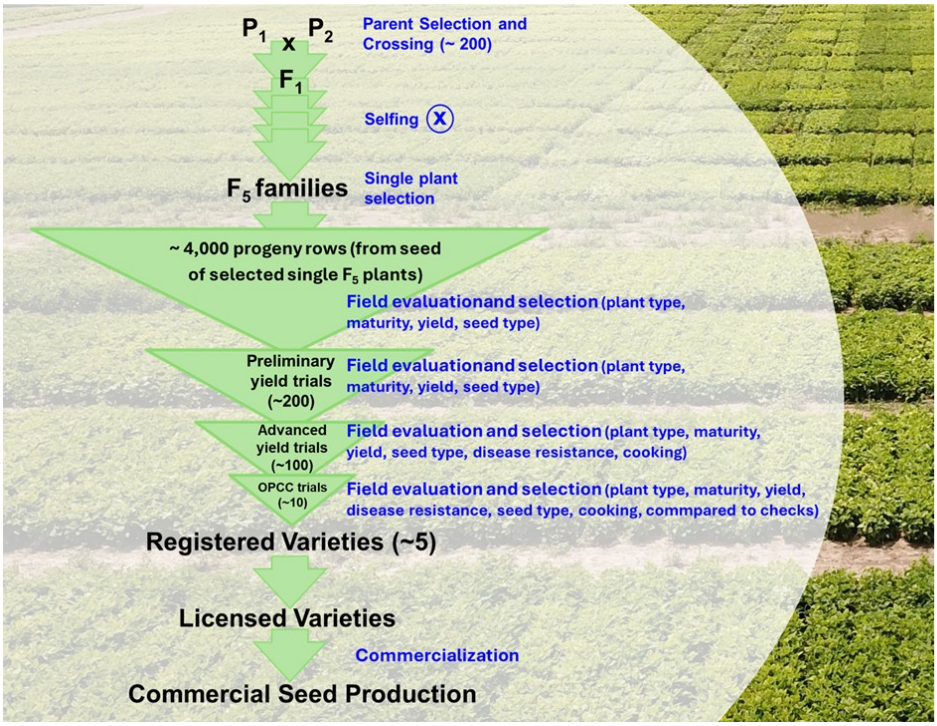

Figure 2. Germplasm movement through the bean breeding program and variety commercialization. https://data.ontario.ca/dataset/ontario-field-crops-production-estimate/resource/02daebd7-a430-4220-83fa-7e7afc3d5efa

Ontario varieties for Ontario growers

The past objectives of the Guelph Bean Breeding Program were to:

- Develop high yielding, disease resistant, novel bean lines for producers in Ontario, Canada, and the rest of the world,
- Discover new knowledge about: – the diversity of Canadian bean breeding germplasm,
    - Genes controlling yield, disease resistance, and atmospheric nitrogen fixing ability
    - Determinants of bean quality, and
    - Bean ecosystem services and sustainability, and
- Educate highly qualified personnel for the pulse industry in Canada.

The current Dry Bean Breeding & Computational Biology Program is developing superior dry bean varieties that enhance yield, resilience, nutritional and cooking quality, and market acceptance by integrating conventional breeding with innovative modern technologies. Its multifaceted approach ensures precise trait selection and breeding efficiency, tailored to Ontario's climate and soil conditions.

Key strategies and ongoing efforts include:

- Innovative breeding methods merging traditional breeding with genomic selection and high throughput phenomics to improve yield, biotic and abiotic stress resistance, and cooking quality;
- Multi-omics approaches to uncover genetic and epigenetic markers, for selection of traits such as seed coat color stability;
- Advanced phenotyping technologies utilizing remote sensing, drone-based imaging, and hyperspectral reflectance to monitor crop health, and predict complex traits;
- AI and computational tools to process complex breeding datasets and accelerate variety development

The current key projects are:

- Multi-omics mapping of seed coat color stability
- High-throughput screening for anthracnose resistance using drone imaging and molecular markers
- AI-powered canning quality assessment pipeline to select high-yield, high-quality varieties, early
- Testing in Ontario Registration and Performance Trials, ensuring that breeding efforts will boost grower profitability, diversify market classes, and be aligned with international sustainable development agendas.

The breeding efforts are supported by genetic studies by graduate students and postdocs, examining: the molecular bases for resistance to common bacterial blight and Anthracnose, genes involved in nitrogen fixation, and the non-darkening seedcoat trait. We are also developing molecular markers for marker assisted selection and sequencing bean genomes to understand the genetic makeup of our germplasm.

We have also explored the ecosystem services provided by a bean crops, showing that crop yields could be increased by increasing the genetic diversity in a field by planting mixtures of varieties instead of monocultures (Reinprecht et al. 2020a). Furthermore, bean varieties that are efficient at fixing atmospheric nitrogen, through symbiotic associations with Rhizobia were identified (Reinprecht et al. 2020b). The overall objective of the cropping systems work was to increase crop production and ecosystem services, simultaneously.

Seed-borne pathogens promoting plant diseases, like common bacterial blight and anthracnose, are responsible for losses in yield and quality worth ~ $25 M for the bean industry in Canada.

The Guelph bean breeding program has developed CBB-resistant lines as well as anthracnose resistant varieties. Our most recently developed navy bean varieties (Blast, OAC Seal and OAC Charm) combine both resistances (visit GoCrops to see their performance histories). Guelph varieties in other market classes, like dark red kidney (Gallantry), white kidney (Snowshoe), cranberry (OAC Firestripe) and black bean (OAC Vortex and Umbra) have shown to be excellent yielders in trials in Ontario, Michigan and Manitoba. Recently, the dark red kidney bean Dynasty was named Seed of the Year.

In the future, as in the past, the central purpose of bean breeding at the University of Guelph is to develop exceptional varieties that will allow growers in Ontario to be world leaders in sustainable bean production.

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