Expectations of plant breeders for the use of genomics and biotechnology in crop (canola) improvement – public and industry perspectives.

Gerhard Rakow
AAFC Saskatoon Research Centre

Applying genomics to canola improvement workshop

December 1, 2005, Hilton Garden Inn, Saskatoon

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Canada

Objective of presentation

- to strengthen discussion and collaboration between genomics researchers and plant breeders, and also producer groups and industry associations on the use of genomic tools in canola breeding.

- to identify areas for research collaboration between genomic researchers and plant breeders, for the application of genomic tools in canola germplasm and variety development.

- to evaluate the usefulness and effectiveness of different genomic tools in canola improvement.

AAFC canola breeding

- we are not involved in the breeding and registration of new *Brassica napus* varieties/hybrids.
- research focus in *B. napus* is on elite germplasm development for use by private industry, preferably through collaborative research projects.
  - meal quality improvement
    - ⇨yellow seeded types with lower fibre content.
    - ⇨glucosinolate reduction or complete elimination.
  - oil quality improvement
    - ⇨high stability oil lines with high oleic acid and low linolenic acid content.
    - ⇨low saturate fat lines.
- all the above in combination with maximum oil content and high protein content.

AAFC canola breeding

Diversification of oilseed production.

- *Brassica juncea* canola has superior heat and drought tolerance (frost tolerance?), is resistant to seed shatter and has high levels of blackleg resistance.
- *Brassica rapa* canola adapted to short season zone production (early maturity), pod shatter resistance, susceptible to diseases.
- *Brassica carinata* canola has superior drought tolerance and excellent disease resistance.
- *Sinapis alba* canola for vegetable oil and high protein meal.

---

for all species:

- herbicide tolerance, disease resistance, hybrid varieties, high quality oil and meal.

Breeding methodology and procedures

- elite germplasm development based on classical breeding approaches
  - cross breeding with pedigree selection.
  - DH inbreeding as a tool for inbred line development.
  - mutation induction and selection.
  - interspecific (intergeneric) gene transfer.
  - disease (race) specific resistance development.
- genetic studies to determine mode of inheritance for seed (oil and meal) and disease resistance traits.
- evaluation of new germplasm and creation of gene pools for hybrid variety development.

Use of genomic tools to enhance germplasm development

- Marker assisted selection (MAS), particularly for traits with low heritabilities.
- Development of mapping populations
  - identification of parents with contrasting phenotypes

    eg. resistance/susceptibility to a disease.
  - making crosses and produce segregating population, preferably based on doubled haploidy.
  - phenotyping of mapping population for trait(s) of interest in field or greenhouse tests as appropriate.

Use of genomic tools to enhance germplasm development

- Development of molecular markers
  - types of molecular markers (RAPD, AFLP, SSR, others).
  - marker-assisted selection alone or in combination with phenotypic selection.
  - marker-assisted backcrossing.
  - variety identification and hybridity testing.
- Result: improve breeding efficiency.

New genomics research project

- Genome Prairie Project: “Designing oilseeds for tomorrow’s markets”
- Research focus is on meal quality improvement:
  - fibre reduction (yellow seed).
  - reduction and, if possible, complete elimination of antinutritive factors such as glucosinolate, sinapine, phytate.
  - carbon partitioning between seed coat and embryo, including oil accumulation.

New genomics research project

- close co-operation between AAFC plant breeders and Canadian genomics researchers (NRC-PBI, U of A, U of M, AAFC), and German research institutes and plant breeders providing elite germplasm for genomics research (yellow seed, low glucosinolate).
- genetic and breeding studies are an integral part of the project to facilitate commercialization of research results in new improved varieties.
- focus on yellow seed colour genetics.
- project start date: January 1, 2006, for 4 years.

Ongoing genomics research on canola in Canada

- transgenic approaches were used by private companies to develop herbicide tolerant canola varieties:
  1) Round-up Ready (glyphosate) tolerant lines and varieties, including hybrids, are developed by Monsanto and other companies.
  2) Liberty Link (glufosinate ammonium) herbicide tolerant hybrid varieties from Bayer CropScience; herbicide tolerance serves also as a mechanism for hybrid seed production.

Ongoing genomics research on canola in Canada

- The development of herbicide tolerant canola varieties was the only genomic development that found practical application in commercial canola production.
- Targeted for producers to improve weed control.
- Herbicide tolerant varieties occupy about 90% of total canola acreage in Canada (75% transgenic).

Basic genomics research

- Genome Prairie Project: “Enhancing canola through genomics.”
- Goal is “to gain functional insights into key genes involved in seed development and composition using genomic tools with the aim of developing new improved canola varieties.”
- much of the work is done in *Arabidopsis*.
- project started April 1, 2003 (3 year project).

Basic genomics research

- Expected results
  - seed development: more uniform growth and maturity of larger seed with thinner seed coats.
  - seed composition: improved proteins at high concentrations and modified oils, reduced levels of anti-nutritive compounds.

- This work requires input from canola breeders as to use of canola germplasm for the research to be done on canola in the future.
- This is a joint project between NRC and AAFC.

Basic genomics research

- Genome Canada Project: "Functional genomics of abiotic stress in cereals and canola (*Brassica).*"
- Major research themes are:
  - low temperature and drought stress including ABA.
  - nutrient and oxygen stress.
  - research on *Brassica* stress factors led by Randall Weselake, U of A, Edmonton.

Basic genomics research

- *Brassica* team mission statement: "Use functional genomics to study the response of *Brassica* species and the related model crucifer, *Arabidopsis thaliana*, to abiotic stress in order to develop strategies to improve *Brassica* stress tolerance and growth under stressful conditions."

- Selection of *Brassica* species germplasm with well-defined differences in heat and drought tolerance based on multiple years of field observations, for use in this research is critical.

Future expectations

- Development and use of molecular markers should increase breeding efficiency.
- Co-ordinated efforts between genomics researchers and plant breeders needed to identify areas in canola breeding that would benefit from use of molecular markers for variety development.
- Development of mapping populations, and their phenotypic characterizations is critical for marker development.
- Utilization of basic genomics research results in *Arabidopsis* in future canola breeding requires more team work, a first step towards this will be done in the new genomics research project: “Designing oilseeds for tomorrow’s markets.”