Improving canola production and production systems with genetic and agronomic advances to increase canola acreage in the Pacific Northwest

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Available Crops

Spring:
- Wheat
- Barley
- Garbanzo
- Lentil
- Pea
- Canola

Winter:
- Wheat
- Canola
- AWP
Pacific Northwest Crops

- **2,615,072 acres**
  - 48% Wheat
  - 44% Fallow

- **1,364,338 acres**
  - 53% Wheat
  - 28% Fallow

- **1,367,453 acres**
  - 54% Wheat
  - 3% Fallow

**Low Rainfall**

- W. Wheat: 1,367,453 acres
- S. Wheat: 537,905 acres
- Barley: 22,057 acres
- Canola: 12,718 acres
- Legume: 35,420 acres
- Fallow: 62,575 acres

**Intermediate Rainfall**

- W. Wheat: 1,364,338 acres
- S. Wheat: 531,453 acres
- Barley: 21,657 acres
- Canola: 12,718 acres
- Legume: 35,420 acres
- Fallow: 62,575 acres

**High Rainfall**

- W. Wheat: 2,615,072 acres
- S. Wheat: 557,453 acres
- Barley: 22,718 acres
- Canola: 12,718 acres
- Legume: 35,420 acres
- Fallow: 62,575 acres
• Yield loss;
• Grass Weeds;
• Diseases;
• Soil Acidification;
• Lack of diversity.
Increase US Canola Acreage

✓ Develop genetically adapted cultivars.
✓ Availability of cultivars resistant to biotic and abiotic stresses.
✓ Good fit into existing production management systems.
✓ Local knowledge of best crop production practices.
✓ Increase grower profitability.
Increase US Canola Acreage
✓ Develop genetically adapted cultivars.
✓ Availability of cultivars resistant to biotic and abiotic stresses.
✓ Good fit into existing production management systems.
✓ Local knowledge of best crop production practices.

More money – More acres
Objectives

✓ Quantify the effects of growing canola in rotations with wheat in the PNW.
## Crop Rotation Effects

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Year 0</th>
<th>Year 1</th>
<th>Year 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID Spring Rotation</td>
<td>Spring wheat</td>
<td>Spring canola</td>
<td>Winter wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring pea</td>
<td>(SWWW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring barley</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring wheat</td>
<td></td>
</tr>
<tr>
<td>ID Winter Rotation</td>
<td>Winter wheat &amp; Fallow</td>
<td>Winter canola</td>
<td>Winter wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Austrian winter pea</td>
<td>(SWWW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Winter wheat</td>
<td></td>
</tr>
<tr>
<td>WA Spring Rotation</td>
<td>Spring barley</td>
<td>Spring canola</td>
<td>Winter wheat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring wheat</td>
<td>(HRWW)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring Garbanzo</td>
<td></td>
</tr>
</tbody>
</table>
Winter Wheat Yield following Spring Rotation Crops

- Winter Wheat: 4,776 kg ha\(^{-1}\) with a decrease of 13%
- Barley: 4,154 kg ha\(^{-1}\) with a decrease of 7%
- Canola: 4,458 kg ha\(^{-1}\) with a decrease of 11%
- Pea: 4,265 kg ha\(^{-1}\) with a decrease of 11%
Spring Rotation 2-Year Returns
Idaho 2018

Grower Gross Return ($’s)

- **Spring Wheat**: $1,800
  - Spring Seed ($882)
  - Spring Wheat ($918)
- **Spring Barley**: $1,576
  - Spring Seed ($780)
  - Spring Barley ($796)
- **Spring Canola**: $1,949
  - Spring Seed ($1,092)
  - Spring Canola ($857)
- **Green Pea**: $1,229
  - Spring Seed ($410)
  - Green Pea ($819)

*Based on commodity seed prices of $0.197 ($5.36 bu\(^{-1}\)) kg\(^{-1}\) for soft white wheat, $0.154 kg\(^{-1}\) for barley ($140 ton\(^{-1}\)), $0.484 kg\(^{-1}\) for canola ($0.183 lb\(^{-1}\)), and $0.276 kg\(^{-1}\) ($0.125 lb\(^{-1}\)) for pea.
Winter Wheat Yield following Winter Rotation Crops

- Winter Wheat: $5,593
- Winter Canola: $6,731
- AWP: $7,029
- Fallow: $5,832

- Winter Canola yield is 20% higher than Winter Wheat.
- AWP yield is 26% higher than Winter Wheat.
- Fallow yield is 4% above Winter Wheat.
Winter Rotation 2-Year Returns
Idaho 2018

<table>
<thead>
<tr>
<th>Crop</th>
<th>Grower Gross Return ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Wheat</td>
<td>$2,397</td>
</tr>
<tr>
<td>Winter Canola</td>
<td>$3,152</td>
</tr>
<tr>
<td>AWP</td>
<td>$1,589</td>
</tr>
<tr>
<td>Fallow</td>
<td>$1,121</td>
</tr>
</tbody>
</table>

*Based on commodity seed prices of $0.197 ($5.36 bu⁻¹) kg⁻¹ for soft white wheat, $0.484 kg⁻¹ for canola ($0.183 lb⁻¹), and $0.276 kg⁻¹ ($0.125 lb⁻¹) for AWP.*
Shallow fibrous root systems of small grain cereal crops do not penetrate deep into the soil profile or reach deep profile nutrients.
Shallow fibrous root systems of small grain cereal crops do not penetrate deep into the soil profile or reach deep profile nutrients.
10” Cylinder + 1 liter water

Time until no more standing water
## Spring Soil Infiltration

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water Infiltration - liters h⁻¹ -</th>
<th>Water Seepage -- cm⁻² --</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Wheat</td>
<td>15.62</td>
<td>23.50</td>
</tr>
<tr>
<td>Spring Barley</td>
<td>40.19</td>
<td>14.84</td>
</tr>
<tr>
<td>Spring Canola</td>
<td>42.90</td>
<td>9.79</td>
</tr>
<tr>
<td>Green Pea</td>
<td>17.38</td>
<td>5.52</td>
</tr>
</tbody>
</table>

Very large variation between samples within crops
## Winter Crop Soil Infiltration

<table>
<thead>
<tr>
<th>Crop</th>
<th>Water Infiltration</th>
<th>Water Seepage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Wheat</td>
<td>5.6 b</td>
<td>60.6 ab</td>
</tr>
<tr>
<td>Winter Canola</td>
<td>27.0 a</td>
<td>44.9 b</td>
</tr>
<tr>
<td>AWP</td>
<td>7.5 b</td>
<td>49.7 b</td>
</tr>
<tr>
<td>Summer Fallow</td>
<td>3.9 b</td>
<td>93.8 a</td>
</tr>
</tbody>
</table>
# Washington Rotation Trials

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TRT</td>
<td>WW</td>
<td>SW</td>
<td>TRT</td>
<td>WW</td>
<td>SW</td>
<td>TRT</td>
<td>WW</td>
<td>SW</td>
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<td>TRT</td>
<td>WW</td>
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<td>SW</td>
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<td>TRT</td>
<td>WW</td>
<td>SW</td>
<td>TRT</td>
<td>WW</td>
<td>SW</td>
<td>TRT</td>
<td>WW</td>
<td>SW</td>
</tr>
</tbody>
</table>

**Treatment crops** → **Recrop winter wheat** → **Spring wheat**
Winter Wheat Yield following Spring Rotation Crop - WA

Winter Wheat: 3,396 Kg ha⁻¹
Spring canola: 3,697 Kg ha⁻¹, +10%
Chickpea: 3,985 Kg ha⁻¹, +17%
Spring Wheat Yield following Winter Wheat Crop - WA

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Yield kg ha⁻¹</th>
<th>% Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter Wheat</td>
<td>2,641</td>
<td></td>
</tr>
<tr>
<td>Spring Canola</td>
<td>2,416</td>
<td>-9%</td>
</tr>
<tr>
<td>Chickpea</td>
<td>2,476</td>
<td>-6%</td>
</tr>
</tbody>
</table>
Spring Rotation 3-Year Returns
Washington

Grower Gross Return ($'s)

<table>
<thead>
<tr>
<th></th>
<th>Spring Wheat</th>
<th>Spring Canola</th>
<th>Chickpea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower Gross</td>
<td>$1,651</td>
<td>$1,641</td>
<td>$1,694</td>
</tr>
<tr>
<td>Seed</td>
<td>$521</td>
<td>$476</td>
<td>$488</td>
</tr>
<tr>
<td>Wheat</td>
<td>$670</td>
<td>$735</td>
<td>$786</td>
</tr>
<tr>
<td>Canola</td>
<td>$461</td>
<td>$430</td>
<td>$420</td>
</tr>
<tr>
<td>Chickpea</td>
<td>$430</td>
<td>$476</td>
<td>$488</td>
</tr>
</tbody>
</table>

*Based on commodity seed prices of $0.197 ($5.36 bu⁻¹) kg⁻¹ for soft white wheat, $0.484 kg⁻¹ for canola ($0.183 lb⁻¹), and $0.276 kg⁻¹ ($0.19 lb⁻¹) for chickpea.*
Objectives

✓ Develop and identify canola cultivars that afford the highest productivity and greatest profitability for different agronomic zones in the PNW.
# New Cultivar Releases

<table>
<thead>
<tr>
<th>Winter Canola</th>
<th>Spring Canola</th>
<th>Indian Mustard</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Chinook’</td>
<td>‘Monarch’</td>
<td>‘Bruin’</td>
</tr>
<tr>
<td></td>
<td>‘Syringa’</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Winter Rape</th>
<th>Spring Rape</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Impress’</td>
<td>‘Industrious’</td>
<td>‘Cataldo’</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Wheat yield loss;
• Grass Weeds.
Winter Canola & Rapeseed

- ‘Chinook’ winter canola (05.WC.15.7.5.IMI), has high yield, exceeding that of ‘Amanda’, and with good agronomic adaptability, high oil content and oil quality, and tolerance to IMI and other Group 2 herbicides.

- ‘Impress’ winter rapeseed (05.WI.45.2.2.IMI), with higher yield than ‘Durola’, excellent winter hardiness, very high seed oil content, and excellent industrial oil quality, and tolerance to IMI and other Group 2 herbicides.

- Chinook and Impress can be planted in rotations where IMI herbicides are used on wheat or legumes.
Spring Canola

• ‘Monarch’ (07.SC.27.19.B3), has specialty oil characteristics and produces High Oleic Low Linolenic (HOLL) quality canola oil suitable for use as non-hydrogenated (zero trans fat) oil in fry processing, while having long shelf-life.

• ‘Syringa’ (07.SI.7.8.8.7.Gly-IMI) has dual (IMI/Group 2 & Glyphosate) herbicide tolerance, allowing it to be planted in rotations where IMI herbicides are used on wheat or legumes with Glyphosate applied in-crop for weed control.
Spring Rapeseed

- ‘Industrious’ (07.SI.8.A10) has higher seed yield potential than ‘Gem’, excellent adaptability to a range of PNW environments, with very high oil content and excellent industrial oil quality.

- ‘Cataldo’ (07.IR.1.5.4.5.Gly-IMI) has excellent oil quality and content and has dual (IMI/Group 2 & Glyphosate) herbicide tolerance, allowing it to be planted in rotations where IMI herbicides are used on wheat or legumes with Glyphosate applied in-crop for weed control.
Spring Brown Mustard

- **Bruin** is a new brown Indian condiment mustard, with brown seed (Dijon type).
- Bruin is tolerant to IMI- and other Group 2 herbicides allowing it to be planted in rotations where IMI-herbicides are used on wheat or legumes.
- Bruin has higher seed yield than ‘Kodiak’, with very high glucosinolates (spice) and can be utilized as a condiment seed crop or as a cover crop or a green manure for soil fumigation.
Cultivar Licensing

- All new cultivars are available for licensing.
- The University of Idaho Office of Technology Transfer manages all cultivar licensing.
- Contact Karen Stevenson at 208-885 4550 or karens@uidaho.edu for more information.
- Companies can elect to license new cultivars on an exclusive or non-exclusive basis.
- Licensees pay the University of Idaho a royalty based on the amount of Certified Seed sold.
Pacific Northwest Cultivar Variety Trials

- Spring and winter cultivar evaluation trials in four PNW States.
- Identify regions specifically suited to spring or winter canola.
- Provide growers information of ‘best’ cultivars.
Field tours:

- Winter Canola Variety Trials: 8 locations, 3-4 speakers, 249 contacts;
- Spring Canola Variety Trials: 8 locations, 2-4 speakers, 322 contacts.
✓ WSU Davenport Field Day: 138 attending
Winter Kill
Cold & Drought Tolerance

✓ Developing cold- and drought-tolerant canola varieties that efficiently utilize water and express extreme winter hardiness is major goal.

✓ The RC12A gene is known to play a significant role in abiotic stress.

✓ The RC12A gene encodes for a plasma membrane-related protein that is specifically related to cold stress tolerance.
Cold & Drought Tolerance

✓ We generated the necessary cDNA’s from both *Arabidopsis* and canola plants.
✓ We generated plant expression constructs overexpressing RC12A genes (Canola *RC12A* gene (*BnRC12A*) and Arabidopsis *RC12A* (*AtRC12A*)) under the control of the strong CaMV 35S promoter.

![Diagram](image-url)
✓ Generated transgenic canola plants overexpressing *BnRC12A* and *AtRC12A* genes by Agrobacterium-mediated transformation and tissue culture.
✓ Two transgenic canola lines overexpressing *AtRC12A* gene have been generated.

Vernalized 35S::AtRC12 transgenic canola plants in greenhouse
Freeze Treatment

°C

Hours

0 2 4 6 8 10 12

-12 -10 -8 -6 -4 -2 0 2 4 6 8 10 12
Freeze Treatment

35S::AtRC12

Amanda
35S::AtRC12

Amanda
Objectives

✓ Survey the PNW’s potential for development of blackleg.
Blackleg in Idaho

- Most important disease of canola in Canadian Prairies and Midwest.
- Was not observed in rainfed areas of PNW until 2011 discovery in Boundary County.
- In 2014, discovered in seed production fields in Nezperce County.
- Widespread during the spring of 2015 in Idaho, Lewis, Nezperce and Latah Counties.
Survey Sites
Summary of survey

✓ 50 Locations surveyed
   Blackleg confirmed at 39 locations (78%)
 ✓ 128 isolates of *L. maculans*
    10 isolates of *L. biglobosa*.
 ✓ Confirmed by pathogenicity tests and PCR.

L. *maculans* mating types

- Type 1: 65
- Type 2: 62
Frequency of *avirulence* genes in Northern Idaho (125 isolates)

- AvrLm1
- AvrLm2
- AvrLm3
- AvrLm4
- AvrLm5
- AvrLm6
- AvrLm7
- AvrLm9
- AvrLm11
- AvrLepR1
- AvrLepR2
- AvrLepR3
Most common genetic races of *L. maculans* in Northern Idaho

- 5-6-7-11-LepR1-LepR2
- 5-6-7-11-LepR1-LepR2-LepR3
- 5-6-7-11-LepR1
- 3-5-6-7-11-LepR1-LepR2
- 5-6-7-11
- 5-6-7-11-LepR1-LepR3
Genetic Resistance

✓ Canola has 14 identified resistance genes (*Rlm*)
✓ Corresponding 14 avirulence genes, 9 are cloned and mapped.
✓ Collected genetic differentials to characterize pathotypes and to better characterize isolates.
### Host Differentials

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Type</th>
<th>Rlm genes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Westar</td>
<td>S. Canola</td>
<td>None</td>
</tr>
<tr>
<td>Columbus</td>
<td>W. Canola</td>
<td>1, 3</td>
</tr>
<tr>
<td>Glacier</td>
<td>W. Canola</td>
<td>2, 3</td>
</tr>
<tr>
<td>Bristol</td>
<td>W. Canola</td>
<td>2, 9</td>
</tr>
<tr>
<td>02.22.2.1</td>
<td>W. Canola</td>
<td>3</td>
</tr>
<tr>
<td>Jet Neuf</td>
<td>W. Canola</td>
<td>4</td>
</tr>
<tr>
<td>Cutlass</td>
<td>S. Mustard</td>
<td>5,6</td>
</tr>
<tr>
<td>01.23.2.1</td>
<td>W. Canola</td>
<td>7</td>
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<tr>
<td>Goeland</td>
<td>W. Canola</td>
<td>9</td>
</tr>
<tr>
<td>Topas</td>
<td>S. Canola</td>
<td>LepR1</td>
</tr>
<tr>
<td>LepR1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topas</td>
<td>S. Canola</td>
<td>LepR2</td>
</tr>
<tr>
<td>LepR2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topas</td>
<td>S. Canola</td>
<td>LepR3</td>
</tr>
<tr>
<td>LepR3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 12 varieties;
- 11 Rlm genes;
- New isogenic lines;
- INRA, AAFC, USDA.
Objectives

✓ Compile and make available a comprehensive PNW Canola Production Manual to growers and local industry to allow them to make decisions on how best to utilize winter and spring canola in their existing crop rotation systems.
Education

**Students**

3 MS Students, 2 graduated last December:

- Breeding;
- Molecular Genetics;
- Pathology.

8 Undergraduate Students:

- Full-time over summer;
- Part-time during semester.
Oral Presentations at Field Days and Grower Meetings

✓ Oregon
  • Pendleton Field Day June 12, 2018  Blackleg Fungicide Trial, 150 attendees.
  • Blackleg in Oregon, presented at US Canola November 6, 2018, Baltimore. 45 attendees.
  • 100+ additional grower/industry contacts.

✓ Idaho
  • Prairie Area Crop Tour, June 26, 2018, 53 attendees, Craigmont ID, ‘PNW Canola Variety Trial’.
  • Boundary County Field Day, June 28, 2018, 12 attendees, Bonners Ferry, ID. ‘PNW Canola Variety Trial’ and ‘Flea Beetle Control in Spring Canola’.
  • Northern Idaho Cereal School, Jan 24, 2019, 21 attendees, Bonners Ferry, ID. ‘Challenges in Canola Production (Weed, Insect and Disease Control in Canola)’. 
Oral Presentations at Field Days and Grower Meetings

✓ Washington

• Prairie Area Cereal School, ‘Challenges in Canola Production (Weed, Insect and Disease Control in Canola)’. Greencreek, ID, Jan 22, 2019, 61 attendees.
• Lewiston Cereal School, ‘Challenges in Canola Production (Weed, Insect and Disease Control in Canola)’. Lewiston, ID, Jan 23, 2019, 58 attendees.
• Washington State Oilseed Cropping Systems Workshop, Wilbur, WA, 125 attendees.
• Washington State Oilseed Cropping Systems Workshop, Clarkston, WA, 150 attendees.
Publications

Thesis:

Conference Abstracts:
Poster Presentations

• Brown J., J.B. Davis and A. Job. New Cultivar Releases from the University of Idaho. Washington State Oilseed Cropping Systems Workshop, Clarkston, WA.
Extension and Outreach Activities in PNW

☑ **WSU-WOCS Oilseed Workshops**
  - 2018: 3 locations, 318 attendees
  - 2019: 3 locations, 306 attendees

☑ **UI Cereal/Grain School**
  - 2018: 6 locations, 425 attendees
  - 2019: 2 locations, 241 attendees

☑ **Field tours:**
  - Variety Trials: 13 locations, ~300 attendees;
  - Other with canola component: ~250 attendees.

☑ **Presentations:** 400+ contacts.
PNW Canola Production, 2013-2017

Source: USDA, National Agricultural Statistics Service

January 2018

Washington State Dept. of Agriculture
Questions

http://www.cals.uidaho.edu/brassica/
http://css.wsu.edu/oilseeds/