Participatory plant breeding for Canadian organic crop production

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Why select crops for organic cropping systems?

• Organic farming systems have unique challenges:
  – Limitations in available soil nutrients
  – Interference from weeds

• Selecting under organic management improves crop performance in organic systems
Farmer involvement in a breeding program can take different forms

1) Variety selection
   Farmers participate in evaluating and selecting advanced lines or varieties

2) Plant breeding
   Farmers participate in selecting segregating populations
Field performance of farmer-selected wheat populations

Farmer participation breeding program started in 2011
• Each farmer is provided with 3 F3 populations
• Plot size: 10 – 20 m² (7,000 seeds provided/pop)

Seeding:
Plots seeded with a garden seeder, modified seeder or by hand
Selection should occur under the same conditions that the crop would typically be grown

**Positive selection** – collect panicles/spikes from plants with desired characteristics and bulk thresh to form next years population

**Negative selection** – pull plants with undesirable characteristics and bulk harvest the rest of the plot
How do farmer selections compare to commercial check cultivars?
Early Season Vigour

Farmer-Selected Checks

1-4 Rating Scale

p = 0.0425
Days to Maturity

$p < .0001$
Leaf Disease at Maturity

<table>
<thead>
<tr>
<th>% of Flag leaf diseased</th>
<th>Farmer-Selected</th>
<th>Checks</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>± 0.2</td>
<td>± 0.3</td>
</tr>
</tbody>
</table>

p = 0.6916
Height

![Bar chart showing height in cm for Farmer-Selected and Checks. The p-value is <.0001.](chart.png)
Lodging

Farmer-Selected

Checks

p < .0001

1-9 Rating Scale

3.0

3.5

4.0
Lodging Scale

Rating = 1

Rating = 3

Rating = 5
Yield

- Yield (kg/ha): 4000 to 4800
- Farmer-Selected: 4700 kg/ha
- Checks: 300 kg/ha

$p = 0.0002$
Thousand kernel weight

Farmer-Selected

Checks

p = 0.0528
Kernel number/unit area

Farmer-Selected: p = 0.0002
How do farmer selections compare to commercial check cultivars?

- Better early season vigour
- Later maturity (4 days)
- No significant difference in flag leaf disease at maturity
- 7 cm taller
- Increased lodging
- Higher yield (107% of checks)
What are farmers selecting for?

- Height
- Straw strength
- Leaf size
- Disease resistance
- Tillering
- Ability to grow with an intercrop
- Competitive ability
- Spike appearance
- Maturity
- Yield
- Seed size
How do farmer selections shape a population?
Lessons Learned

• The individual + selection environment has a large influence on the population

• Farmer-selected populations appear better adapted to organic production

• Farmers want a say in parents
Participatory Wheat and Oat Breeding - 2014
Participatory wheat and oat breeding model

Cross parental lines

F1-F2: increase seed

F3-F5: on-farm selection (bulk plots, select spikes)

Continued selection on-farm

Increase seed and develop markets

F6: hill (spike) plot, select plot

F7: row plot, select plot

F8: yield test (unreplicated multiple locations)

F9-F10: yield test (replicated multiple locations)

Registration tests
Participatory Potato Breeding
PPB Potato Selection Process

Cross made at AAFC

Plant seed in greenhouse

Harvest mini-tubers

Distribute mini-tubers to farmers (500 tubers/population)
## Populations available for planting in 2013

<table>
<thead>
<tr>
<th>Popul’n</th>
<th>Female</th>
<th>Male</th>
<th>Harvest</th>
<th>Segregation for skin colour</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>King Harry</td>
<td>V1002-2</td>
<td>466</td>
<td>White</td>
<td>326 oblong, 140 round</td>
</tr>
<tr>
<td>2</td>
<td>NY121</td>
<td>V1002-2</td>
<td>448</td>
<td>448</td>
<td>240 oblong, 208 round</td>
</tr>
<tr>
<td>3</td>
<td>Chieftain</td>
<td>AC CHALEUR</td>
<td>474</td>
<td>174</td>
<td>Lt red</td>
</tr>
<tr>
<td>4</td>
<td>F01031</td>
<td>Redsen</td>
<td>468</td>
<td>408</td>
<td>Red</td>
</tr>
<tr>
<td>5</td>
<td>Island Sunshine</td>
<td>AC CHALEUR</td>
<td>465</td>
<td>465</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Multa</td>
<td>Redsen</td>
<td>445</td>
<td>375</td>
<td>Lt red</td>
</tr>
<tr>
<td>7</td>
<td>Reddale</td>
<td>A11272-02</td>
<td>472</td>
<td>68</td>
<td>Red</td>
</tr>
<tr>
<td>8</td>
<td>Reddale</td>
<td>AC CHALEUR</td>
<td>496</td>
<td>387</td>
<td>Lt red</td>
</tr>
<tr>
<td>9</td>
<td>Redsen</td>
<td>AC CHALEUR</td>
<td>483</td>
<td>381</td>
<td>Red</td>
</tr>
<tr>
<td>10</td>
<td>ROCHDALE GOLD DOREE</td>
<td>AC CHALEUR</td>
<td>438</td>
<td>438</td>
<td>Yellow</td>
</tr>
<tr>
<td>11</td>
<td>Saginaw Gold</td>
<td>AC CHALEUR</td>
<td>447</td>
<td>447</td>
<td>Yellow</td>
</tr>
<tr>
<td>12</td>
<td>FV12486-2</td>
<td>V1002-2</td>
<td>486</td>
<td>408</td>
<td>244 Lt red, 164 purple</td>
</tr>
</tbody>
</table>
PPB Potato Selection Process

Cross made at AAFC

Plant seed in greenhouse

Harvest mini-tubers

Distribute mini-tubers to farmers (500 tubers/population)

Plant 500 hills/population

Select approximately 50 tubers/population
Year 1 On-farm Selection

- Harvest all hills
- Select approx. 50 hills
- Keep 1 tuber/selected hill for planting
PPB Potato Selection Process

Cross made at AAFC

Plant seed in greenhouse

Harvest mini-tubers

Distribute mini-tubers to farmers (500 tubers/population)

Plant 500 hills/population

Select approximately 50 tubers/population

Plant approx. 50 tuber units/population

Select approx. 15 tuber units/population

Research station

On-farm selection year 1

On-farm selection year 2
PPB Potato Selection Process

On-farm selection year 1
- Plant 500 hills/population
- Select approximately 50 tubers/population
- Plant approx. 50 tuber units/population
- Select approx. 15 tuber units/population
  - Plant 40 tubers of each selected unit
    - Evaluate agronomic characteristics, yield and tuber appearance
  - Plant 40 tubers of each selected unit
    - Evaluate yield, disease resistance and baking/boiling quality

On-farm selection year 2

On-farm selection year 3

Research stn.
What have we learned from the PPB program?

• Some farmers are not confident in their ability to make selections
• Having farmers participate in parental line selection is very beneficial
• Farmers that are dissatisfied with currently available varieties will put the most effort into improving their populations
Thank you!