Strategy and Application of Introgression Breeding in Lentil (*Lens culinaris* Medikus)

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*University of Saskatchewan*
• Canada is the world’s biggest exporter of lentil.
• Catching more attention as a wholesome food.
• High nutrition value
• Bio-active Components
  – Improving colonic function, decreasing risk factors associated with obesity and metabolic syndrome

Rich in oligosaccharides, mainly raffinose family oligosaccharides (RFOs).

[Tosh et al., 2013]

Issa et al., 2013
RFOs

- Anti-nutrients: non-digestible, leads to flatulence and other physiological discomforts.
- A major barrier of lentil consumption
- Controlling of anti-nutrients
  - Supplements and processing: heating, soaking, de-hulling, fermentation---negative effect

- Using breeding to reduce RFOs?
Major challenge in lentil breeding

• One of the oldest crops.

(Tanksley and McCouch, 1997)

• Founder effect: loss of allele diversity during domestication process.

• Creating genetic variation: the foundation of crop improvement cycle.

(Zamir, 2001)
Introgression breeding

- Increasing breeding value by expanding the genetic base.
- Using exotic germplasm to transfer desirable traits to a commercially elite variety.
• Lens genus: 6 taxa
• Germplasm collection

Tertiary genepool

L. nigricans

Secondary genepool

L. ervoides
L. odemensis
L. lamottei
L. tomentosus

Primary genepool

L. culinaris
L. orientalis
(Wild progenitor)

Wong et al., 2015
• *L. ervoides*: the potential genetic donor

• Wild species
  – Overcome crossing barriers
  – Phenotyping both positive and negative traits
  – Speed up the breeding procedure
    • Marker-assisted selection
The interspecific *L.c.* *L. e.* crosses

### Cross barrier

Embryo rescue

<table>
<thead>
<tr>
<th></th>
<th>Total RFO</th>
<th>Raffinose</th>
<th>Stachyose</th>
<th>Verbascose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Enzyme-based)</td>
<td>(HPAEC-PAD)</td>
<td>(mMoles/100 g)</td>
<td>(mg/100g)</td>
</tr>
<tr>
<td>LR-26</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eston (<em>L.c.</em>)</td>
<td>4.54a</td>
<td>70</td>
<td>252</td>
<td>73</td>
</tr>
<tr>
<td>IG 72815 (<em>L.e.</em>)</td>
<td>2b</td>
<td>70</td>
<td>192</td>
<td>158</td>
</tr>
<tr>
<td>LR-59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eston (<em>L.c.</em>)</td>
<td>5.03a</td>
<td>84</td>
<td>321</td>
<td>108</td>
</tr>
<tr>
<td>L01-827 A (<em>L.e.</em>)</td>
<td>2.85 b</td>
<td>84</td>
<td>217</td>
<td>207</td>
</tr>
</tbody>
</table>
• Mapping introgression: RILs populations

Selfing
SSD
Green house

LR-26
173 RILs plus parents,
F8:12 SSD derived

LR-59
66 RILs plus parents,
F7:12 SSD derived
Morphological segregation

**Distribution of plant height of LR-26**
- IG72815: 46.5
- Eston: 52.25

**Distribution of plant height of LR-59**
- L01-827A: 32
- Eston: 53

(L.c.)
- 1: White with blue vein
- 2: Purple vein
- 3: Purple vein
- 4: Purple

(L.e.)
- 1: Purple
- 2: Purple
- 3: Purple
- 4: Light purple

**LR-26 Flower color**
- 1: White
- 2: Purple
- 3: White
- 4: Light purple

**LR-59 Flower color**
- 1: Purple
- 2: Purple
- 3: Purple
- 4: Light purple

**Cotyledon color**
- LR-26: Y 46%, R 54%
- LR-59: Y 51%, R 49%
Potential for grain quality improvement

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Sucrose</th>
<th>TRFO</th>
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<tbody>
<tr>
<td>Genotype</td>
<td>85</td>
<td>19.82**</td>
<td>4.07**</td>
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<tr>
<td>Residual</td>
<td></td>
<td>1.70</td>
<td>0.29</td>
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<tr>
<td>Residual df</td>
<td>163</td>
<td>164</td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>249</td>
<td>250</td>
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</tr>
<tr>
<td>CV</td>
<td></td>
<td>14.07</td>
<td>9.74</td>
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</table>

**Significant at \( P \leq 0.01 \).

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>MSE</th>
<th>StDev</th>
<th>Min</th>
<th>Q1</th>
<th>Med</th>
<th>Q3</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>TSW LR26</td>
<td>172</td>
<td>23.05</td>
<td>1.53</td>
<td>20.09</td>
<td>5.17</td>
<td>7.73</td>
<td>16.63</td>
<td>25</td>
<td>34.19</td>
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<tr>
<td>TSW LR59</td>
<td>67</td>
<td>14.82</td>
<td>0.61</td>
<td>4.96</td>
<td>5.17</td>
<td>10.62</td>
<td>14.14</td>
<td>18.52</td>
<td>29.81</td>
</tr>
</tbody>
</table>
For agronomic traits

Distribution of days to emerge of LR-26 (2014)

Distribution of days to emerge of LR-59 (2014)

Distribution of vegetative period of LR26

Distribution of vegetative period of LR59

Eston 9.3
IG 72815 20
L01-827A 23

Eston 10

Eston 29
IG 72815 36
L01-827A 27.3

Eston 27
Negative effects

LR-26 Dehiscence

LR-59 Dehiscence

LR-26 Lines with Seedling chlorosis symptoms

LR-59 Lines with Seedling chlorosis symptoms

Lines with Seedling chlorosis symptoms
On-going wild lentil introgression studies

- Mapping introgression using LR26 and LR59
- Improving bio-fortification and stress tolerance.
- Using other wild species to expand genetic base for future genetic gain in lentil breeding.

<table>
<thead>
<tr>
<th>Inter-specific</th>
<th># RILs</th>
<th>Intra-specific</th>
<th># RILs</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.c. * L.ori.</td>
<td>8</td>
<td>L.e. * L.e.</td>
<td>1</td>
</tr>
<tr>
<td>L.c. * L.ode.</td>
<td>3</td>
<td>L.ori * L.ori.</td>
<td>3</td>
</tr>
<tr>
<td>L.c. * L.t.</td>
<td>3</td>
<td>L.tom * L.tom</td>
<td>2</td>
</tr>
<tr>
<td>L.c. * L.e.</td>
<td>2</td>
<td>L.ode * L.ode.</td>
<td>1</td>
</tr>
<tr>
<td>L.c * L.l.</td>
<td>1</td>
<td>L.l * L.l</td>
<td>1</td>
</tr>
<tr>
<td>Lt * L.ori.</td>
<td>1</td>
<td>L.n * L.n</td>
<td>1</td>
</tr>
<tr>
<td>L.ori. * L.t.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Thank you for the attention.

Questions?