Kevin Smith – University of Minnesota
Malt U – BSG & Rahr Malting

Barley Breeding for Malting and Brewing
Breeding Better Barley for Brewing Better Beer

- Barley Market Classes:
  - 2-row, 6-row, spring, winter
- Production Traits
- Quality Traits
- Breeding Pipeline
Barley Varieties Planted in Midwest

Barley varieties persist for many years
University of Minnesota Barley Breeding

**SPRING BARLEY**

- 6-Row
  - Manchuria (1918)
  - Minsturdi (1922)
  - Svansota (1926)
  - Velvet (1926)
  - Peatland (1926)
  - Glabron (1929)
  - Regal (1931)
  - Mars (1945)
  - Forrest (1957)
  - Cree (1957)
  - Manker (1974)
  - Morex (1978)
  - Robust (1983)
  - Excel (1990)
  - Stander (1993)
  - MNBrite (1998)
  - Forrest (2000)
  - Lacey (2000)
  - Rasmusson (2008)
  - Quest (2011)

- 2-Row

**WINTER BARLEY**

- 6-Row
- 2-Row

- Started 2009
- Started 2012
- Started 2013
2-ROW
Plump
Higher Extract
Lower DON
Lower Protein

6-ROW
Higher Amylase
Higher yield in Midwest
Better leaf disease resistance
2-ROW

6-ROW

Vrs1

1H 2H 3H 4H 5H 6H 7H

Barley Chromosomes
Spring Barley and Winter Barley
Spring Barley and Winter Barley

Double Cropping
**Agronomic Benefits:** increased yield, disease avoidance, weed suppression, water use efficiency, nitrogen use efficiency

**Ecosystem Services:** carbon sequestration, nutrient cycling, reduced erosion, wildlife habitat

**Producer/Industry Benefits:** crop diversity, spread out field activities, double cropping, earlier harvest

Photos taken in late April
Challenge: winter hardiness
Production Traits

Heading Date
Days to Maturity
Lodging
Disease Resistance
Yield
Grain Pumpness
Grain Protein
Production Traits

Heading Date
Days to Maturity
Lodging
Disease Resistance
Yield
Grain Plumpness
Grain Protein

Stem Rust
Production Traits

- Heading Date
- Days to Maturity
- Lodging
- Disease Resistance
- Yield
- Grain Plumpness
- Grain Protein

Powdery Mildew
Production Traits

Heading Date
Days to Maturity
Lodging
Disease Resistance
Yield
Grain Plumpness
Grain Protein

Fusarium head blight
## Quality Traits

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<th>Wort protein</th>
<th>S/T protein</th>
<th>Diastatic power</th>
<th>Alpha amylase</th>
<th>FAN</th>
<th>Beta-glucan</th>
<th>Viscosity</th>
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### AMBA Guidelines

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<td>Total Protein</td>
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## Quality Traits

- Malt extract
- Wort protein
- S/T protein
- Diastatic power
- Alpha amylase
- FAN
- Beta-glucan
- Viscosity

### Table: Quality Traits

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<tr>
<th>Variety or Selection</th>
<th>Rowed</th>
<th>Kernel Weight (mg)</th>
<th>6/64°</th>
<th>Barley Color (Agronomy)</th>
<th>Malt Extract (%)</th>
<th>Wort Color</th>
<th>Wort Clarity</th>
<th>Barley Protein (%)</th>
<th>S/T (%)</th>
<th>DP</th>
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*Univ of Minnesota, Driven to Discover™*
Quality Traits

Malt extract
Soluble (wort) protein
S/T protein
Diastatic power
Alpha amylase
FAN
Beta-glucan
Viscosity

Flavor?
Breeding Pipeline

Year | Stage | Description
--- | --- | ---
1 | Crossing Block | Parents (greenhouse)
2-3 | Inbreeding | F1 (greenhouse), F2 (field), F3 (greenhouse), Winter Nursery
6-7 | Industry Testing | Pilot Malting, Plant-scale Brewing
8 | Release |
## Breeding Pipeline

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<td>Plant-scale Brewing</td>
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<tr>
<td>8</td>
<td>Release</td>
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</tbody>
</table>

- **Select parents and Perform Cross pollinations**
- **Parent A**
  - yield
  - disease resistance
  - protein
  - malt extract
  - FAN
- **Parent B**
  - yield
  - disease resistance
  - protein
  - malt extract
  - FAN
Pollination

1 stygma (female)

3 anthers (male)
Breeding Pipeline

**Year**

1. **Crossing Block**
   - Parents (greenhouse)

2-3. **Inbreeding**
   - F1 (greenhouse)
   - F2 (field)
   - F3 (greenhouse)
   - Winter Nursery

4-5. **Line Evaluation**
   - Prelim. Yield Trials
   - Adv. Yield Trials

6-7. **Industry Testing**
   - Pilot Malting
   - Plant-scale Brewing

8. **Release**
Breeding Pipeline

Year 1
- Crossing Block: Parents (greenhouse)
- Inbreeding: F1 (greenhouse)
- F2 (field)
- F3 (greenhouse)
- Winter Nursery

Year 2-3
- Line Evaluation: Prelim. Yield Trials
- Adv. Yield Trials

Year 4-5
- Industry Testing: Pilot Malting
- Plant-scale Brewing

Year 6-7
- Release

Single row plots
Breeding Pipeline

Year 1
- Crossing Block
  - Parents (greenhouse)
  - F1 (greenhouse)
  - F2 (field)
  - **F3 (greenhouse)**
  - Winter Nursery

Year 2-3
- Inbreeding
  - Prelim. Yield Trials
  - Adv. Yield Trials

Year 4-5
- Line Evaluation
  - Pilot Malting
  - Plant-scale Brewing

Year 6-7
- Industry Testing

Year 8
- Release
Breeding Pipeline

**Year**

1. **Crossing Block**
   - Parents (greenhouse)

2-3. **Inbreeding**
   - F1 (greenhouse)
   - F2 (field)
   - F3 (greenhouse)
   - **Winter Nursery**

4-5. **Line Evaluation**
   - Prelim. Yield Trials
   - Adv. Yield Trials

6-7. **Industry Testing**
   - Pilot Malting
   - Plant-scale Brewing

8. **Release**

**New Zealand**
Breeding Pipeline

Year  | Event                        | Notes
-----|-------------------------------|-------
1     | Crossing Block               | Parents (greenhouse)
2-3   | Inbreeding                   | F1 (greenhouse)  
       |                               | F2 (field)  
       |                               | F3 (greenhouse)  
       |                               | **Winter Nursery**
4-5   | Line Evaluation              | Prelim. Yield Trials  
       |                               | Adv. Yield Trials
6-7   | Industry Testing             | Pilot Malting  
       |                               | Plant-scale Brewing
8     | Release                      |
Breeding Pipeline

Year 1
- Crossing Block: Parents (greenhouse)

2-3
- Inbreeding: F1 (greenhouse)
- F2 (field)
- F3 (greenhouse)
- Winter Nursery

4-5
- Line Evaluation: Prelim. Yield Trials (3 locations)
- Adv. Yield Trials

6-7
- Industry Testing: Pilot Malting
- Plant-scale Brewing

8
- Release

2 rows, 10’ long
<table>
<thead>
<tr>
<th>Year</th>
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<th>Activities</th>
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<td></td>
<td>F3 (greenhouse)</td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>4-5</td>
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<td>Prelim. Yield Trials</td>
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<tr>
<td></td>
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## Breeding Pipeline

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</tbody>
</table>

**Fusarium Head Blight Nursery**
Breeding Pipeline

Year | Activity | Notes
--- | --- | ---
1 | Crossing Block | Parents (greenhouse)
2-3 | Inbreeding | F1 (greenhouse)
 |  | F2 (field)
 |  | F3 (greenhouse)
 |  | Winter Nursery
4-5 | Line Evaluation | Prelim. Yield Trials
 |  | **Adv. Yield Trials (5 locations)**
6-7 | Industry Testing | Pilot Malting
 |  | Plant-scale Brewing
8 | Release |
Breeding Pipeline

**Year 1**
- Crossing Block
- Parents (greenhouse)

**2-3**
- Inbreeding
- F1 (greenhouse)
- F2 (field)
- F3 (greenhouse)
- Winter Nursery

**4-5**
- Line Evaluation
- Prelim. Yield Trials
- Adv. Yield Trials

**6-7**
- Industry Testing
- **Pilot Malting**
- Plant-scale Brewing

**8**
- Release

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**QUALITY EVALUATION SUBCOMMITTEE**

2016 Crop Pilot Scale Program

**Midwest Nursery Selections**

**M160 Unsatisfactory** (MI39/FEG160-03) This third year selection had slightly high barley protein and slightly low extract. It was rated unsatisfactory in 2015 testing with slightly high wort turbidity. It was satisfactory in 2014 crop testing with slightly high turbidity. No further testing.

**S6M164 Unsatisfactory** (MS10S4021-013/MS10S4058-024) This second year selection had slightly high barley protein and beta-glucan and slightly low extract. It was rated satisfactory in 2015 testing with slightly high beta-glucans. No further testing.

**S6M166 Unsatisfactory** (MS10S4034-018/MS10S4029-013) This second year selection had good extract, and slightly high S/T and beta-glucan. It was rated satisfactory in 2015 testing with good extract and slightly high beta-glucans.

**S6M168 Unsatisfactory** (MS11S3058-014/MS11S3080-19) This first year selection had high barley protein, wort viscosity and beta-glucans, and low extract and friability.

**ND32889 Satisfactory** (ND28479/ND25652) This first year selection had slightly high wort viscosity and turbidity.

**ND32898 Satisfactory** (ND28479/ND25652) This first year selection had slightly high wort viscosity and turbidity.
Breeding Pipeline

Year | Stage | Events
--- | --- | ---
1 | Crossing Block | Parents (greenhouse)
2-3 | Inbreeding | F1 (greenhouse), F2 (field), F3 (greenhouse), Winter Nursery
6-7 | Industry Testing | Pilot Malting, Plant-scale Brewing
8 | Release |
Project Members / Key Collaborators

Barley Project
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- Karen Beaubien
- Jerry Franckowiak
- Ana Poets
- Celeste Falcon
- Tyler Tiede
- Alex Olhoff
- Lu Yin
- Jeffrey Neyhart
- John Price
- Ian McNish
- Becky Zhong

University of Minnesota
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- Aaron Lorenz
- Ruth Dill-Macky
- Brian Steffenson
- Yanhong Dong
- Madeline Smith

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- Joshua Butler, Busch Ag.
- Jean-Luc Jannink, USDA
- USDA-CCRU
- Mark Sorrels, Cornell
- Jamie Sherman, Montana State U
- Gongshe Hu, USDA Aberdeen

Logos: American Malting Barley Association, U.S. Wheat & Barley Scab Initiative, SMALL GRAINS INITIATIVE, University of Minnesota Agricultural Experiment Station, USDA, Minnesota Department of Agriculture, University of Minnesota

University of Minnesota
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Questions