



Breeding Multi-Use Naked Barley for Organic Systems

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Barley (*Hordeum vulgare*)

- Fourth most widely grown cereal in the world
- Second most widely grown organic small grain in US
- 2.05 million acres grown in US (2018)



Barley end-uses

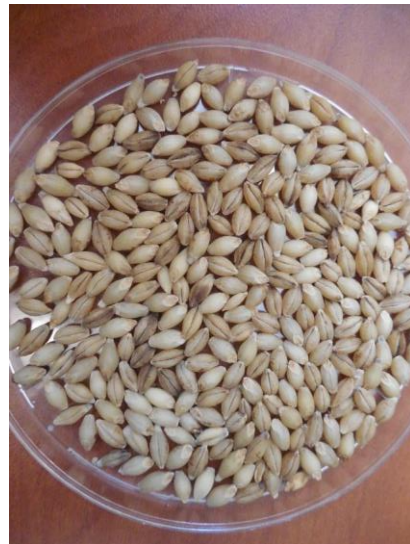
- Feed/Forage
- Malt
- Food



Covered



Naked



The *Nud* Gene

- Controls the naked vs. covered phenotype
- Arose by spontaneous mutation ~6500 BCE
- Single locus on chromosome 7HL
- *Nud* allele present: lemma and palea adhere to the kernel
- *nud* allele present: lemma and palea thresh freely

Traits of Interest related to *nud*

- Threshability
- Resistance to embryo damage/germination
- Seedling vigor
- Emergence/establishment
- Yield
- Disease resistance
- β -glucan content





Threshability

- Ease of hull removal
- Canadian standards
 - Food grade: 5% grain with undetached hulls
 - Feed grade: 15% grain with undetached hulls
- Controlled by two genes
- Good threshability associated with rounder grains and thin hulls
- Scored visually

Resistance to Embryo Damage

- Poor or uneven germination
- Size and shape of grain
- Cultural practices during harvesting and cleaning
- Adjust combine settings
- Visual scoring and germination testing



Yield

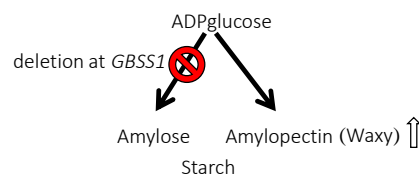
- Naked barley is reported to yield less than covered barley
- Poor emergence, germination, or reduced seedling vigor can have an effect on yield
- Expect 10-13% lower yields due to lack of hull
- Higher seeding rate recommended
- Less breeding devoted to naked barley
- Several studies show that naked barley breeding lines can compete with covered lines



Choo et al. 2001; Thomason et al. 2009; Meints et al. 2015

Grain β -glucan and waxy starch

- There are qualitative and quantitative genetic components to grain β -glucan
- Waxy trait controlled by a recessive mutation in the granule-bound starch synthase 1 (*GBSS1*) gene (*wx* allele)



- Normal starch contains ~25% amylose and waxy starch has 0-10% amylose
- Breeders can select for higher grain β -glucan by targeting the recessive allele

Patron et al., 2002

Seed coat color

- Blue and purple contain anthocyanins, black contain melanin
- Purple and black located in pericarp, blue in aleurone layer (exhibits xenia)
- Black, purple, and blue seed coats are found predominately in landraces from areas of the world where barley remains a staple crop



Buckley, 1930; Bellido et al., 2009; Faris, 1955; Myler and Stanford, 1942; Woodward, 1941; Woodward and Thieret, 1953

Breeding for Organic Systems

- Most barley varieties bred for conventional systems
- Selections made under organic conditions are often better suited for organic production systems
- Target:
 - Disease resistance
 - Weed competition
 - Input-use efficiency





Diseases

- Stripe rust
- Leaf rust
- Stem rust
- Scald
- Covered smut
- Loose smut
- Ergot
- Barley Yellow Dwarf Virus
- Powdery mildew

Weeds

- Stand counts
- Early vigor ratings
- Early plant height
- Weed counts in plots
- Growth habit
- Canopy coverage



Winterhardiness:

- Growth habit: Winter, spring, facultative
- Score for winter survival
- Frost damage
- Collaborative nurseries



Feed Barley

- 75% of world barley acres for animal feed
- Breeding naked feed barley began in ~1970s in Canada for monogastric feed
- Hull has no benefit for non-ruminants
- By early 2000s, 24 naked barleys released and ~750,000 acres of naked barley being grown in western Canada

Feed Barley

- Digestible energy (DE) and/or Metabolizable energy (ME)
- Breeders target high levels of DE, high starch, low non-starch polysaccharides
- High levels protein
- β -glucans are problematic



Feed Barley

- Naked barley is a superior feed for swine
- Can also be a good feed for poultry
 - β -glucan is an issue, especially for young chicks
 - Older hens and roosters handle it better
- Naked barley can also be a good energy source for cattle
- Our study:
 - Layer hens
 - Broilers



Malt Barley

- Barley is the optimum substrate for malting and brewing/distilling
- Nearly all malt barley bred with a hull
 - Protects acrospires
 - Helps with filtration during lautering
- Advances in brewing technology, including mash filters can mitigate this
- Naked barley has the potential to have significantly higher levels of malt extract and improved beer quality



Malt Barley

- Concerns with malting naked barley:
 - Higher screening losses
 - High temps during kilning can result in low friabilities due to case-hardening
 - High β -glucan
- Breeders can select for:
 - Softer kernels
 - Large kernels
 - Round, short grains
 - Low/moderate β -glucan

Malt Barley

- Modification and protein levels can be problematic
- May be necessary to adjust steep and germination schedules to successfully malt naked barley
- Multi-step steep and longer germination resulted in:
 - Higher steep-out moistures
 - Higher friability
 - Lower β -glucan levels
 - Higher Kolbach Indices
- Our study:
 - Pilot malts
 - Looking at colored barley for malting
 - Using CLP to determine appropriate steep and germination regime



Edney and Rossnagel 2000; Stewart et al. 2004; Swanston and Middlefell-Williams 2012; Krstanovic et al. 2015



Brewing

- Limited data on brewing trials
- Theoretical advantages:
 - Economic benefits associated with storage costs
 - Higher extract levels
 - Potential quality advantages
 - Improved physical stability in finished beer
- Studies have used 50-100% naked barley successfully
- Our study:
 - Two naked lines + covered check
 - Compared using lauter tun and mash filter by OSU Fermentation Science

Distilling

- The distilling community is interested in naked barley for whiskey due to increased alcohol yields
- Research has shown that malt modification may be more important for rapid filtration than the hull
- Using a modified malt schedule, researchers found that naked malt had good levels of amylolytic enzymes
- Naked malts produced wort with shorter filter times and higher predicted spirit yield than the covered check



Agu et al. 2009; Swanston and Middlefell-Williams 2012

Food Barley

- Rich traditional and culinary significance in many cultures around the world
- In US, barley has almost disappeared as a food
- On the rebound due to increased knowledge of the benefits of fiber and whole grain nutrition
- Clinical studies show the positive effects of β -glucan on human health
 - Lowering post-prandial blood glucose levels
 - Lowering plasma LDL cholesterol concentrations
 - Protection against mutagenic agents



Health claims for barley

- In 2006, the FDA approved a health claim for barley. It allows:

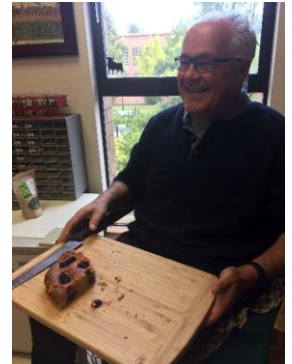
*“foods containing barley to claim that they **reduce the risk of coronary heart disease**. Specifically, **whole grain barley** and dry milled barley products such as **flakes, grits, flour, and pearled barley**, which provide at least **0.75 grams of soluble fiber per serving**” (21 CFR 101.81)*

- European health claim in 2011 and Canadian health claim in 2012



Food Barley

- Can be used in multiple applications
 - Flour
 - Grits
 - Flakes
 - Steamed
 - Toasted
 - Extruded
- Has potential in numerous food products
 - Risen and flat breads
 - Pastries
 - Pancakes
 - Cookies
 - Noodles
 - Tortillas
 - Tea



Food Barley

- Targets for Breeders:

- β -glucan content
- Protein
- Kernel hardness
- Whole grain nutrition
- Functionality
- Minerals
- Antioxidant capacity



VS.



<http://www.herbalremedies.com/>; www.iberb.com

Effects of β -glucans

- β -glucans are the most important factor influencing flour yield
 - Genotypes with high levels of β -glucan resist breakdown and produce a greater proportion of larger sized particles during roller milling
 - Low β -glucan varieties contain less β -glucan and have thinner cell walls, making them easier to mill
- Alteration of dough properties
 - Dramatic increase in water absorption
 - Increased dough strength
 - Reduced dough resistance to extension
 - Impacts on starch pasting properties, lowered gel viscosity, increasing gelatinization temperature



Bhatty 1997; Wood 2007; Izydorczyk and Dexter 2008

Sensory Exploration

- Hedonic, preference, and descriptive tastings
- Steamed grain, bread, crackers, digestives, biscuits, roasted tea, hot steep
- Flavor, texture, aroma, color, overall



'Developing Multi-use Naked Barley for Organic Farming Systems'

- Funded by USDA-NIFA-OREI in 2017 for three years
- Participating states: Oregon, Washington, Minnesota, Wisconsin, and New York
- Research, extension, education components
- Evaluate agronomic, food, feed, and malting and brewing performance under organic conditions
- Measure the economic, environmental, and health benefits of organic naked barley production and products



Key Resources

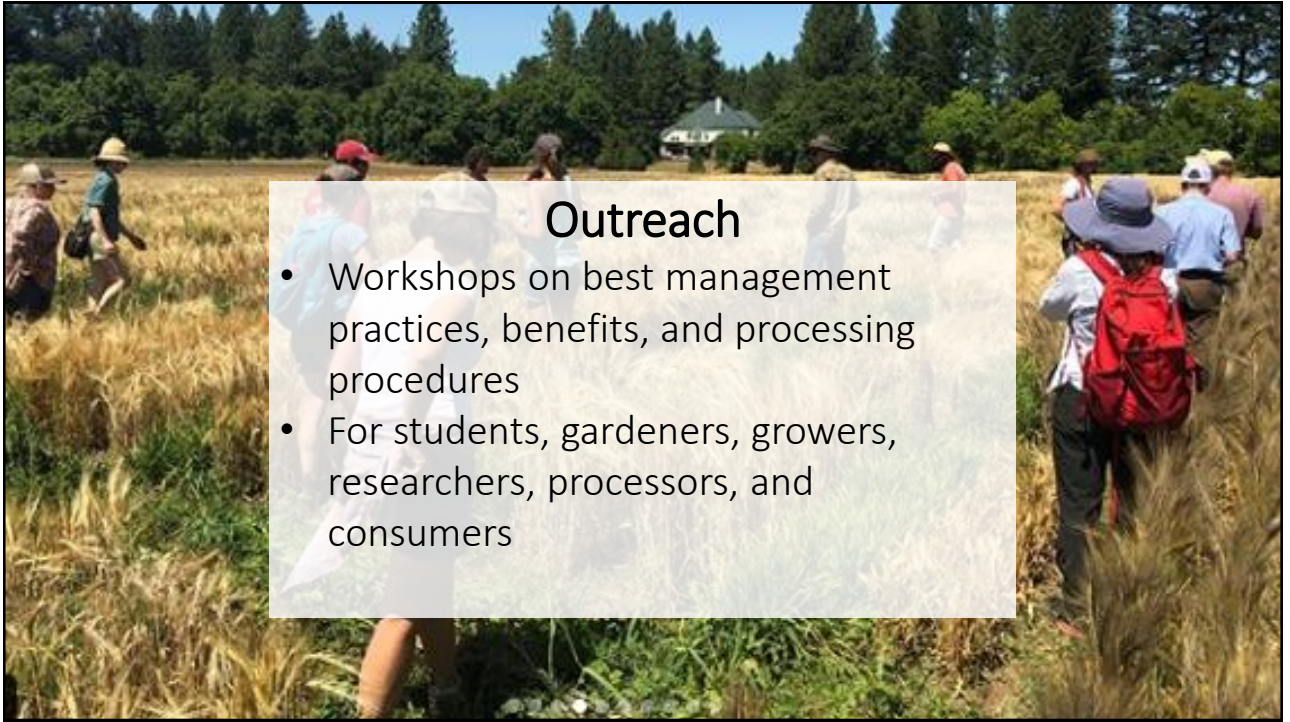
- *Oregon Naked Barley Blend (ONBB)*:
 - A fun and educational blend of 753 pure lines
- *The diversity panel*:
 - 384 genetically diverse lines for improving barley in organic systems
- *Multi-region agronomic and yield trials*:
 - 20 advanced naked lines
- *On-farm production*:
 - For large-scale evaluations of farm to finished product performance

Field Trials



- Regional fall and spring yield trials
- Fall and spring diversity panel
- Assess for agronomic traits, weed competitiveness, resistance to biotic and abiotic stresses
- Assess for quality traits
- GWAS on diversity panel





Outreach

- Workshops on best management practices, benefits, and processing procedures
- For students, gardeners, growers, researchers, processors, and consumers

Outreach Opportunities

- Barley Day
- CBN Variety Showcase
- Organic Seed Growers Conference
- Organicology
- The Grain Gathering
- Cascadia Grains Conference
- Workshops and classes
- Greenmarket Grains



Education

- Each state has a lead teacher
- Collaborate on lesson plans
- Fieldtrips
- Classroom visits
- Math, science, agriculture, nutrition



Conclusions

- Breeding multi-use naked barley can give organic farmers a second or third option for sales
- Should have moderate levels of β -glucan and normal starch
- Farmers, processors, producers, and consumers can benefit from naked barley, education is necessary for acceptance

Acknowledgements and Further Resources

- Thanks to all collaborators on the grant and the Barleyworld crew!
- Developing Multi-use Naked Barley for Organic Farming Systems: USDA-NIFA-OREI Grant 2017-51300-26809
- Web: eorganic.info/barley and barleyworld.org/orei-project
- Instagram and Facebook: [@multibarley](#)
- Ideas for future naked barley webinars? Email: brigid.meints@oregonstate.edu

