Research to Commercialization Collaboration Opportunity: Pre-Harvest Sprouting Resistant Wheat

Background: The global wheat industry loses as much as $1 billion a year due to prolonged rainfall and high humidity which cause grains to germinate before they are fully mature. Pre-harvest sprouting (PHS) has a high economic cost for both growers and end-users. As the seed germinates starch and protein are degraded reducing the quality of the seed. Flour from the degraded seed will produce products that are porous, sticky, off color and generally of poor quality. If the grain has over four percent damaged kernels then it is unacceptable for human food products. A portion of sprouted grain may be used for animal feed reducing the price by 20% to 50%. Significant damage causes a total loss as blending is difficult or impossible without ruining the quality of the entire blend.

Recent published research indicates two areas that may be useful to improving wheat PHS.

1. Incorporating the TaPHS1 allele conferring partial PHS resistance into current varieties.
2. Testing mutations in seed-specific versions of the Trx h9 gene which may improve PHS.

Each of these two areas are explained below along with proposed experiments.

Incorporating the TaPHS1 allele conferring partial PHS resistance into current varieties

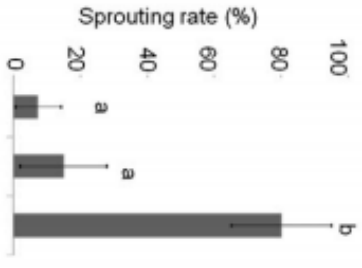
The gene underlying a wheat PHS chromosome 3A QTL was recently cloned.[1] The original source of the partial PHS resistance for this QTL was from the white seeded variety Rio Blanco. Wheat varieties in Kansas vary for the presence or absence of the desirable TaPHS1 found in Rio Blanco conferring PHS tolerance. Identifying sources of PHS among other germplasm groups, including those from Montana would aid greatly in the development of PHS resistance germplasm.

Proposed TaPHS1 experiments:

1. Screen commonly grown varieties and breeding material for TaPHS1 sequence variation.
2. Measure PHS on the same set of genotypes.
3. Determine role of TaPHS1 sequence variation in PHS for selected varieties.
4. Cross desirable TaPHS1 alleles into select varieties to improve PHS.

Below is a key figure from Liu et al. demonstrating the impact of the Rio Blanco TaPHS1 allele upon PHS. The TaPHS1 allele from Rio Blanco is associated with reduced PHS. The frequency of this preferred allele among wheat germplasm is not known. Our goal would be to find desirable alleles, determine their role in PHS and develop germplasm useful in breeding.

Haplotype groups	-222	+646	+666	Cultivar number	Sprouting rate (%)
I (Rio Blanco type)	C	G	A	20	7.2
II (Chinese Spring type)	T	G	A	46	15.1
III (NW97S186 type)	T	A	T	16	79.5



Testing whether mutations in seed-specific versions of the Trx h9 gene may improve PHS.

Thioredoxin h is a key regulator of proteins in seeds and is involved in regulating seed germination. It was recently demonstrated that knocking out expression of Thioredoxin h9 (Trx h9) via a transgenic process in wheat endosperm delays germination enough to drastically reduce PHS.[2] However, it is not known whether there exists seed specific forms of Trx h9 that could be knocked out via mutagenesis. Knocking out Trx h9 in seeds alone is critical to avoid disrupting overall plant growth.

Proposed Thioredoxin experiments:

1. Determine expression level of each Trx h9 gene in wheat in roots, leaves, and developing seeds.
2. Identify genome specific copies of the Trx h9 gene most prevalent in seeds.
3. Identify mutations in each Trx h9 seed specific gene. (MSU has several developed and well characterized spring wheat EMS populations.)
4. Determine PHS in seeds from each individual Trx h9 mutation to identify the role of each gene in PHS.
5. Combine mutations by crossing. Measure PHS in segregating populations.

Below is a figure showing improved PHS after knocking out endosperm expression of Trx *h9*.[3]
It is not known whether Trx h9 exists as a gene family in wheat or whether one or more Trx h9 genes are expressed solely or predominantly in seeds. The goal would be to decrease Trx h9 in seeds alone via mutagenesis and develop germplasm useful to incorporate this trait into varieties.

Figure 1. Spikes from homozygous transgenic plants (lower) and null segregants (upper) 7 d after treatment to induce pre-harvest sprouting. (A colour version of this figure can be found online at http://journals.cambridge.org/ssr).

Key references:

[1]Liu, S., S. K. Sehgal, et al. (2013). Cloning and characterization of a critical regulator for pre harvest sprouting in wheat. Genetics 195(1): 263-273.

[2]Li, Y.C., B. Buchanan, et al. (2009). The level of expression of thioredoxin is linked to fundamental properties and applications of wheat seeds. Molecular Plant Vol. 2 (3): 430-441.

[3]Ren, J-P., Y. Li, J.H. Wong, L. Meng, M.-J. Cho, B.B. Buchanan, J. Yin and P.G. Lemaux (2012). Modifying thioredoxin expression in cereals leads to improved pre-harvest sprouting resistance and changes in other grain properties. Seed Science Research, 22, pp S30-S35 d

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