Get Out Your Hard Hats, The Numbers Are Falling

Wide-spread problems with low falling numbers in 2016

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Unpredictable weather is one of the biggest challenges faced in wheat farming, and Mother Nature proved especially fickle toward the end of the 2016 crop year in the Pacific Northwest.

While ample rainfall gave excellent grain yields, ill-timed rain and fluctuations in temperatures led to serious financial losses due to discounts resulting from low falling numbers (FN). Both problems are due to the presence of the alpha-amylase enzyme in grain, evidence that the sprouting process has begun.

Alpha-amylase is produced naturally during grain germination in order to degrade long starch chains into simpler carbohydrates for use as food by the germinating embryo/seedling. This digestion of long starch chains into shorter starch chains reduces the capacity of the starch to gel when heated and, therefore, has a negative impact on the quality of baked goods. Damage from alpha-amylase results in sticky noodles, cakes that fall and bread that doesn't rise well.

The Hagberg-Perten falling number test has been the wheat industry standard for detecting starch degradation since 1968. During the FN test, a slurry of flour and water is stirred and heated for 60 seconds in a glass tube. Then a plunger is dropped, and the machine measures the length of time in seconds that it takes to fall through the water/flour slurry. This is the falling number.

Shorter starch chains do not gel as well as longer starch chains, allowing the plunger to fall faster and giving a lower falling number. Research has shown that an FN below 300 seconds can begin to have a negative impact on the end-use quality of baked goods. A little bit of alpha-amylase (around FN 300 seconds) can be a good thing in baking, but too much causes problems. While bakers sometimes add amylase to a mixture, they cannot remove alpha-amylase from dough. Hence, low FN wheat is marketed at a discount. Low FN as a result of alpha-amylase activity mainly results from two causes: preharvest sprouting caused by rain and late maturity alpha-amylase caused by temperature fluctuations.

Preharvest sprouting is the initiation of germination in mature grain on the mother plant when it rains before harvest. The induction of alpha-amylase under these conditions is a natural consequence of seed germination. Higher seed dormancy results in higher resistance to sprouting, accounting for 60 to 80 percent of the variation. Dormant seed cannot germinate under normally favorable conditions.

Since dormancy is lost through a period of dry after-ripening, mature wheat becomes less dormant and more sprout susceptible the longer it stands in the field. Thus, differences in the apparent susceptibility of varieties depend on the timing of the rain event relative to when the crop matured. Dormancy is also lost by a process called cold stratification. That's when the grain takes up water under cool temperatures in the 50s to 60s. Thus, even wheat that has just turned from green to gold (less than 30 percent moisture) may sprout if cool and rainy conditions persist for several days.

Late maturity alpha-amylase (LMA) is a genetic defect leading to the induction

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of alpha-amylase when plants experience either a high or low temperature shock during the late maturation phase of grain development (26 to 30 days past pollen shedding). Low falling numbers due to LMA are notoriously inconsistent, due in part to this narrow developmental window of susceptibility. For example, only one spike may be affected on a single plant. While preharvest rain events have been rare in the PNW, temperature fluctuations are fairly common. This can lead to low FN problems without rainfall.

Sprouting and LMA susceptibility are controlled by completely different genes. This complicates selection of higher FN varieties. Different varieties have appeared more or less susceptible to low FN depending on whether the wheat encounters LMA, sprout or both LMA and sprout-inducing weather. The weather this year triggered both sprouting and LMA, sometimes in the same field.

The location of the amylase enzyme in the grain provides a clue as to whether it experienced sprout or LMA. During sprouting, an embryo signal triggers higher amylase activity at the germ end of the grain. LMA results in random patches of amylase throughout the grain, so that there are little or no differences in amylase activity at the germ and brush end of the grain. Based on half-seed assays, both preharvest sprouting and LMA occurred in soft white winter wheat in Pullman and Anatone in 2016. In Pullman, Bruehl and Xerpha had amylase from preharvest sprouting, while SY-Assure and SY-Ovation had amylase production from LMA (Figure 1).

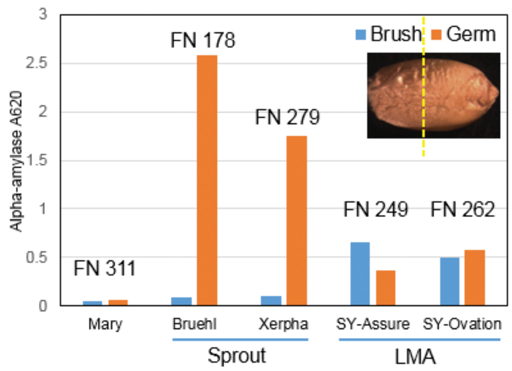
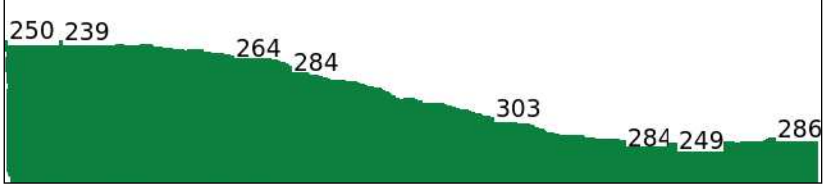


Figure 1. Half-seed assays show that both preharvest sprouting and LMA occurred in Pullman, Wash., in 2016. Thirty grains of each cultivar were cut in half, milled and Phadebas® alpha-amylase enzyme assays were performed on the embryo/germ and brush-end halves. LMA was observed in SY-Assure and SY-Ovation, whereas preharvest sprouting was observed in Bruehl and Xerpha.

Figure 2. Preliminary data showing the variation in FN for SY-Ovation planted on a gentle slope at the Cook Conservation Farm in 2016. Samples were kindly provided by Haiying Tao and Dave Huggins. Distances between samples beginning at the top of the slope were 40, 480, 40, unknown, 200, 40 and 480 ft.



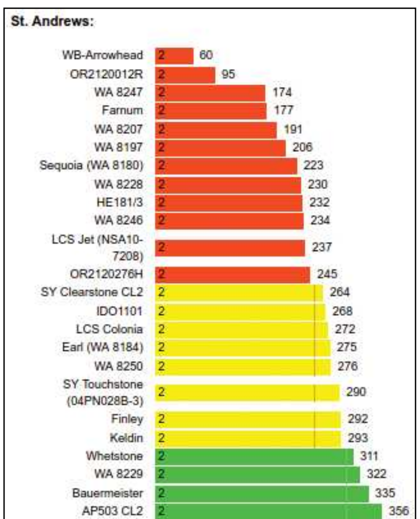


Figure 3. Falling numbers of hard winter wheat from the WSU Cereal Variety trial in St. Andrews 2016. Bars in red represent an FN below 250 seconds, bars in yellow between 300 and 250 seconds, and bars in green above 300 sec.

The variability in FN was examined using SY-Ovation harvested from different positions on a gentle slope at the Cook Conservation Farm in 2016. As shown in Figure 2, SY-Ovation showed a range of falling numbers from 239 to 303 seconds. In Pullman in 2016, Bruehl had FN values of 166, 214, 257 and 278 seconds in four plots within one field. Compare this to Pullman in 2013 when Bruehl had FN values of 153, 161 and 131.

The highly variable weather this year caused a great deal of variation in the timing of wheat maturation in different parts of a field. This combined with conditions capable of inducing either LMA or sprouting probably led to a high degree of variation in falling numbers.

The 2016 problems with low FN were more widespread than in previous years. Of the 20 soft white winter Washington State University Cereal Variety Testing sites, 16 locations had cultivars with FNs below 300 seconds, and 13 locations had cultivars below 250 seconds. In 2013, only seven of the 20 soft white winter sites had FNs below 250 seconds (visit our website at steberlab.org/project7599.php). Washington farmers were not alone in having low FN problems this year. Low FN also occurred in Idaho and Oregon and as far away as Utah and Colorado.

White wheat is generally more susceptible to preharvest sprouting than red wheat, because red wheat has more seed dormancy. But in 2016, many hard red winter cultivars had falling numbers well below 250 seconds in Ritzville, St. Andrews and Lamont (Figure 3). We suspect that this was due to long periods of cool and rainy weather. However, half-seed amylase assays will be needed to confirm this.

The best way to prevent low FN is to select varieties with higher genetic resistance. The Washington Grain Commission-funded project, "Developing Washington Wheat with Stable Falling Numbers (FN) through resistance to preharvest sprouting and LMA" is working to release adapted cultivars with improved preharvest sprouting and LMA resistance.

Farmers can use the PNW Falling Numbers website (steberlab.org/project7599.php) to identify varieties with better falling numbers. Better soft white spring wheat varieties include SY-Saltese, Seahawk, Louise and JD. Better soft white winter varieties include Mary, Skiles, Puma, SY107, WB528, WB456 and Masami. Better winter clubs include ARS-Crescent, Coda and Cara. Farmers, however, need to balance FN considerations with other important traits like disease resistance, freezing tolerance and emergence. It can be especially challenging to choose an FN resistant wheat that emerges well from deep planting.

For instance, good-emerging lines like Bruehl and Xerpha are highly susceptible to low FN. Although Pritchett and Otto are moderately susceptible to sprout and LMA, they are not as susceptible as Bruehl and Xerpha and may provide a better FN alternative for drier locations where deep sowing is necessary. ■

Frequently asked questions about low falling numbers

What is the falling number (FN) test? What exactly does it measure, and why is this important to the buyers of PNW wheat?

The grain trade has adopted FN as a risk management tool. When FN is below 300 seconds, the chance that alpha amylase (AA) enzymes are active increases exponentially. High AA activity, indicated by low (<300) falling numbers, is a danger in grain because the digested starch compromises the ability to produce good quality products.

What are the end-use quality effects of low FN in wheat and high AA?

The effect depends on the product. Low FN and high AA activity are harmful to any product that depends on the gravy-like viscosity produced by starch. AA is highly detrimental in high-moisture, batter-based products like cakes, muffins and batter coatings. High fat and sugar doughs, like cookies, can tolerate some AA activity. In bread baking, AA is actually added in many commercial formulas but this only works if there are some intact starch granules.

What are the causes of low FN?

There are two main causes of low FN: 1) preharvest sprouting, the initiation of germination by cool, rainy conditions after the wheat turns from green to gold; and 2) late maturity alpha amylase (LMA), caused by a large temperature increase or decrease during grain maturation (26-30 days past pollen shedding).

Why is the falling number test so variable?

Variation can result from: 1) micro-environments within the field leading to variation in the FN of harvested grain; 2) sampling error inherent in collecting a small grain sample that represents a truckload or bin; and 3) variability inherent in the testing procedure itself.

How important are genetics and environment in influencing FN?

Both genetics and environment influence FN. Genetics is responsible for about 15 percent of the total variation for FN based on ratings of the Washington State University variety trials. The environment is responsible for about 40 percent. To compare, 15 percent of the total variation for grain yield is due to genetics, and 75 percent is due to the environment, with the rest due to other factors.

Can FN be increased if I store my grain?

Studies are limited but suggest that grain may slightly recover from low FN following storage, especially at a higher temperature. An increase in FN of 50 seconds was observed with 3 months of storage at 100 degrees F. However, increases may also be due to sampling. If all the grain is stored and a second sample taken, that sample may represent a different part of the field that had higher FN.

Can I blend low FN grain with high FN grain to increase the average FN in the grain lot?

Low FN grain can't be reliably mixed with high FN grain to increase the average above 300. As little as 5 percent grain with low falling numbers can significantly decrease the falling number of a larger sample of grain with a FN above 300. Very large quantities of high FN grain are required to blend up low FN wheat. Most growers do not handle the quantities needed to blend up FN. ■

The complete list of FAQs compiled by WSU Extension can be found on the front page of wagrains.org.

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