# FALLING NUMBERS

## RESEARCH STRATEGIES TO STAY OUT OF THE RED

By Camille M. Steber, Arron H. Carter, and Michael O. Pumphrey

Farmers who already balance a myriad of factors when choosing a particular wheat variety to plant now have a new concern to consider: a variety's susceptibility to low falling numbers (FN).

Depending on an elevator's discount schedule, varieties with an FN below 300 seconds can be discounted 25 cents per bushel for every 25 seconds they fall below 300. In 2013, such discounts cost Washington farmers millions of dollars. The Washington Grain Commission-funded project, "Developing Washington Wheat with Higher Falling Numbers," is aimed at reducing the risk of low FN by breeding for genetic resistance. The data from this project can also help farmers choose cultivars with more resistance to low FN. For a more in-depth review of low FN and its causes, see the 2013 *Wheat Life* article at public.wsu.edu/~csteber/publications.html#WheatLifeMagazine.

PHOTO COURTESY OF USDA-ARS

Camille Steber, research plant molecular geneticist, looks over the heads of an array of varieties undergoing a misting test at Washington State University's wheat greenhouse. Steber's research aims to ferret out varietal differences resulting in low falling numbers and incipient sprout.

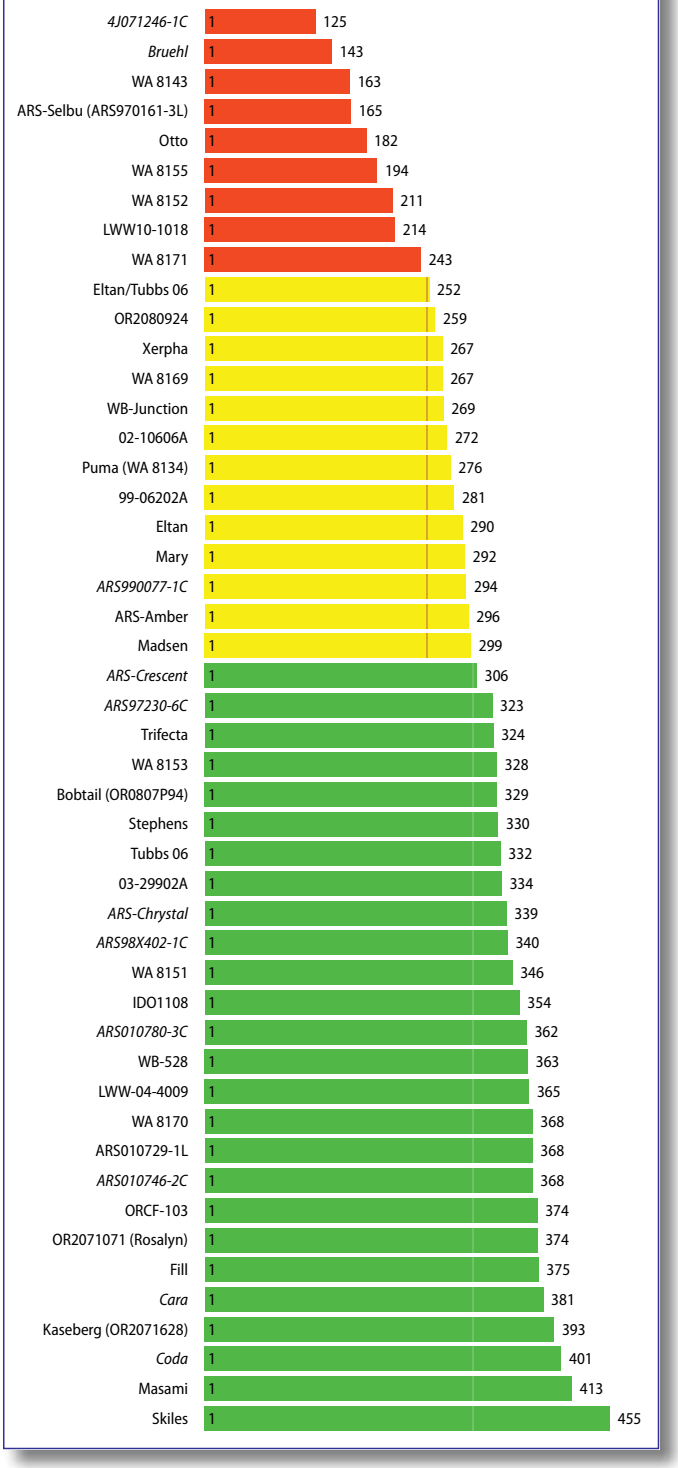
The Hagberg-Perten Falling Number Test measures damage to starch caused by amylase enzyme activity in the flour. The method takes advantage of the fact that a mixture of wheat flour in water will gelatinize upon boiling—just like making gravy. But starch chains cleaved by alpha-amylase fail to gelatinize well.

The FN method is simple. A slurry of flour and water is shaken for 60 seconds, upon which the sample is inserted into the falling number instrument. How long it takes for an inserted stirrer to fall to the bottom of the tube in seconds is the FN number. The more alpha-amylase in the sample, the faster the stirrer falls, the lower the falling number. An FN around 300 is ideal for making bread, cakes and noodles. Although bakers can add more alpha-amylase to their dough, they cannot remove it, hence the discounts. Making matters worse, even a small increase in alpha-amylase content has a big effect on FN and end-use quality.

There are two environmental causes of low FN/high alpha-amylase. Preharvest sprouting is caused by rain, while late maturity alpha-amylase (LMA) is caused by a temperature shock during grain maturation. The problems, while similar in presentation, are different in origination. Genetic resistance to sprouting does not make wheat resistant to LMA, and LMA resistance does not prevent preharvest sprouting.

Australian researchers were the first to describe LMA which is caused by a cold shock between 26 and 30 days after pollen shedding. LMA can also occur in response to a heat shock. We tend to suspect LMA if we see low FN in cases when there was no rainfall around harvest. LMA testing of soft white spring varieties in the greenhouse detected problems in Washington and Idaho breeding lines. But we did not detect problems in most well-established cultivars. This suggests that genetic susceptibility to LMA may be a fairly recent problem for the Pacific Northwest.

**Figure 1:** Falling number results at Lamont




Preharvest sprouting is the initiation of germination when mature grain gets wet. The growth of the germinating wheat embryo is fueled by sugars produced when alpha-amylase breaks down the starchy endosperm. In extreme cases of preharvest sprouting, you can see visible signs of sprout. In mild cases, alpha-amylase can be induced before there is any visible sign of sprout. This

A misting table speeds up the process of replicating precipitation at harvest, but for some varieties, very little moisture, including morning dew in draws, is all that is needed to set off the process of starch converting into sugars.

early induction of amylase results in lower FN. In highly susceptible varieties, very little rain is needed to trigger this amylase production. Some say even mist hanging in draws can trigger mild sprouting.

Rain, which brought wide-spread FN problems in 2013, produced the perfect year to screen for genetic resistance to preharvest sprouting in breeding lines and in Washington State University variety trials. FN testing has now been completed for at least one plot of each available wheat variety and location in the WSU Cereal Variety Trials. This data is publicly available at steberlab.org/project7599.php. This website shows data organized both by location (all varieties, one location, like Lamont in Figure 1), and by variety (one variety, all locations as in Figures 2 and 3).

Wheat cultivars are most resistant to sprouting at maturity, just after the wheat turns yellow, and then becomes increasingly susceptible after maturity as seed dormancy is lost. This is why harvesting the wheat quickly after maturity reduces the risk of rain-induced low FN. Growing two varieties with different maturity dates means a single rain event may affect one line less than the other. In comparing sprouting tolerance of different varieties, it's important to either control for this or to make comparisons over multiple years and locations.

By comparing 2013 FN over multiple locations, a picture begins to emerge showing which locations had rain-induced low FN, and which were most susceptible. Due to the timing of the rain relative to maturity date and harvest date, the low FN problems were more severe

in winter than in spring wheat.

The winter variety trial locations with severe, rain-induced FN problems were Fairfield, Pullman, St. John, Reardan and Lamont. Less severe problems were seen in Colton, Farmington, Walla Walla and Moses Lake. For spring wheat, the most severe low FN problems were seen in Fairfield, Endicott and St. John. Some problems were also seen in Dayton and Mayview. While Pullman, Reardan and Lamont had major FN problems in winter wheat, they had no problems in spring wheat.

The Falling Numbers website shows bar charts where:

- FN over 300 is in green
- FN between 250 and 300 is in yellow; and
- FN below 250 is in red.

The bar shows average FN for the indicated number of plots (number on bar). In the "by variety" view, the dots indicate the average FN for each location. We strongly encourage growers to check out the website since it is much easier to see these differences than it is to describe them (steberlab.org/project7599.php).

Bruehl (Figure 2), shows FN in the red at six locations, and FN in the yellow at five locations out of 19. Bruehl is so susceptible that it would

**Figure 2:** Falling number results for Bruehl by location

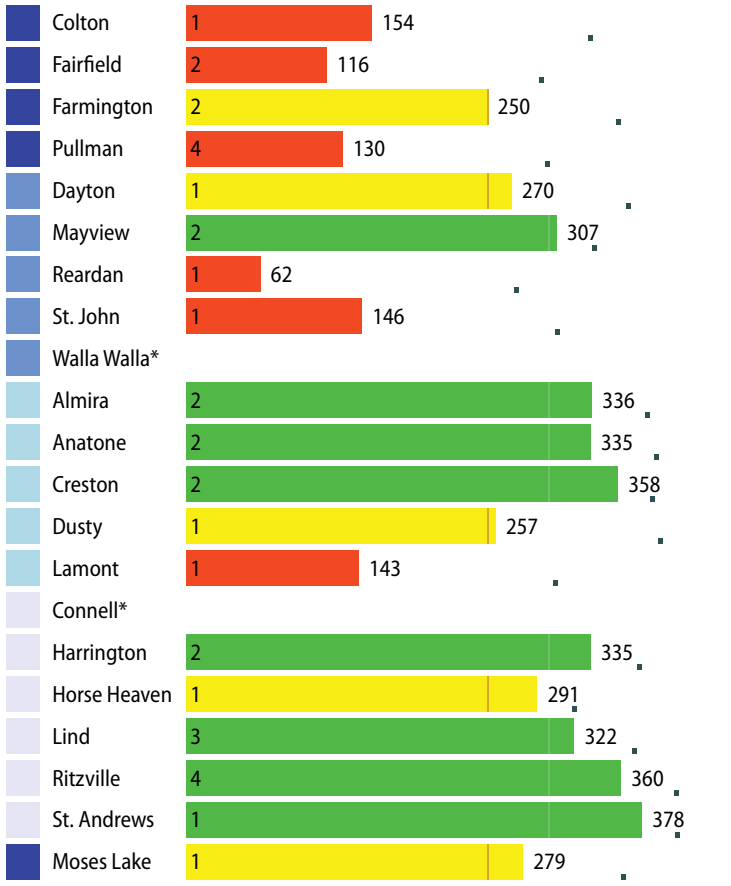



**Figure 3:** Falling number results by variety

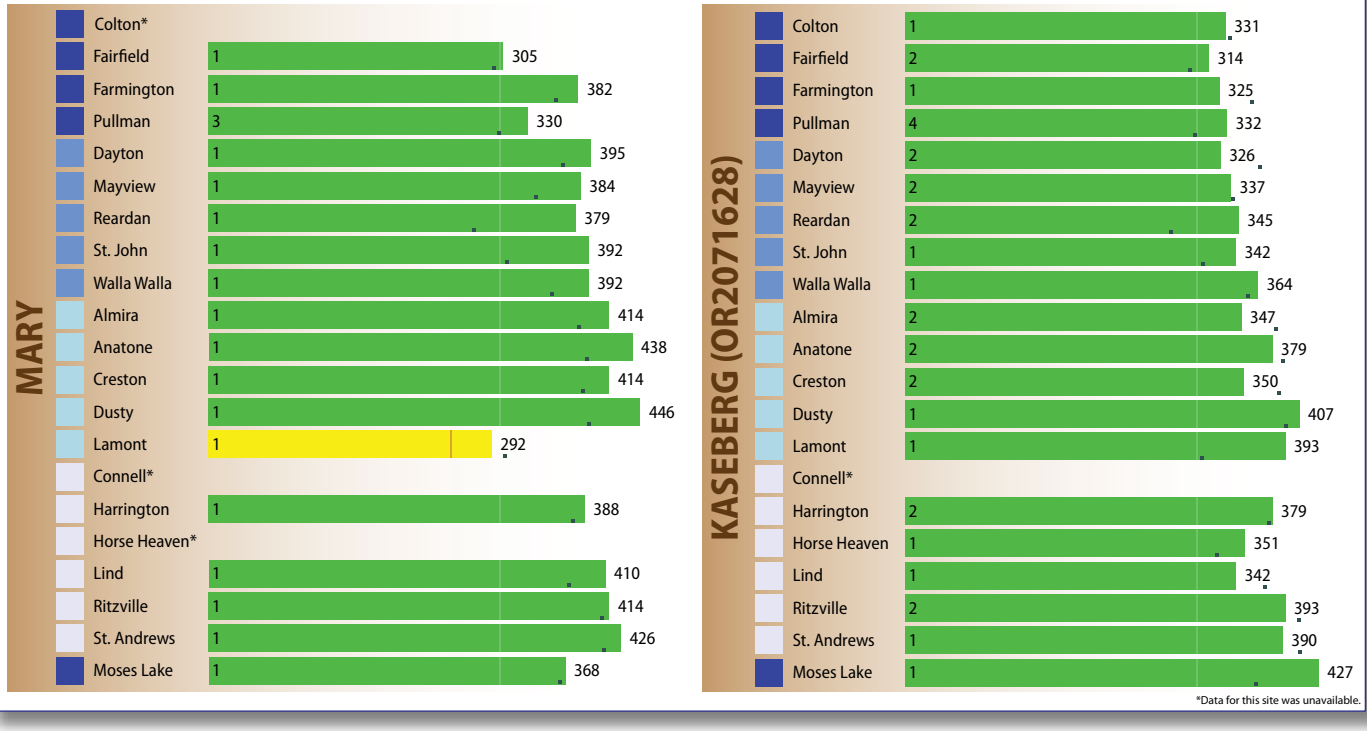
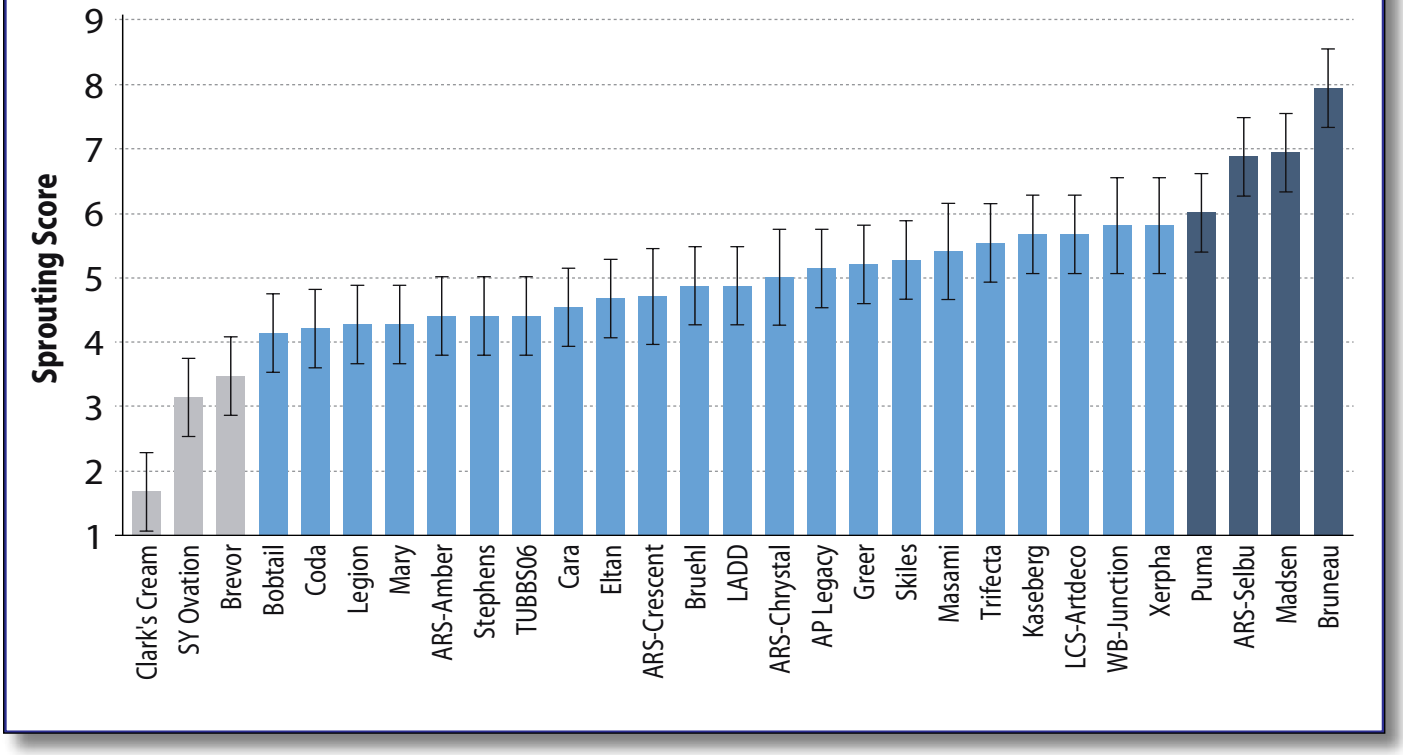


**Figure 4:** Sprouting scores from the spike wetting test. A higher score means more sprouting




make a good sprout-detector for the cereal variety trials. Other cultivars with FN in the red at three or more locations include Xerpha, AP Legacy, Bruneau and ARS-Selbu. Eltan had one location in the red and four yellow, whereas WB-Junction had two red and three yellow.

The good news is that there are numerous soft white winters showing FN in the green (greater than 300) over many locations. Masami, Kaseberg and Ladd had FN in the green at every location examined (Figure 3). Varieties with FN in the yellow (250-299) at only one location include Mary, Cara, Bobtail, Stephens, LCS-Artdeco and Legion.

Soft white springs Alpowa, JD and Zak had FN solidly in the green, whereas Alturas, Diva and WB-1035CL+ had FN in the yellow at three or more locations. Although there are some exceptions (Bullseye, three red) little or no low FN was observed in hard wheat.

A spike wetting test scores wheat for visible sprouting during one week on a misting table (Figure 4). This test controls for variations due to differences in maturity date by harvesting all the lines at maturity, then storing them in the freezer until it is time to put all the wheat spikes on the misting table.

Visible sprout scoring does not tell exactly the same story as FN scoring in 2013. Bruneau's tendency to have rain-induced low FN is associated with a tendency to sprout easily in the rain (high sprouting score in Figure 4). But the tendency of Bruehl, Xerpha and Eltan to have rain-induced low FN is associated with an intermediate sprouting score rather than a high sprouting score. Also, Kaseberg tends to have high FN, but does sprout after six days of misting. This means that rain-induced low FN needs to be scored separately from rain-induced germination.

Our website provides an abundance of information about cultivar susceptibility to low FN in the rain. It is up to the farmer, meanwhile, to weigh the risks of low FN against other factors like yield. Please look for your favorite cultivar on the website and decide how much risk is acceptable. For example, Bruehl is favored in the dry areas because it emerges well from deep planting. Unfortunately, it is also highly prone to rain-induced low FN.

Growers who want to use a susceptible cultivar may consider planting a second cultivar with a different maturity date and higher resistance to low FN. That way, if it rains after the wheat matures, the two cultivars can be harvested and stored separately in the hope that part of the crop won't be discounted for low FN. ■