# 2.2 The benefits and costs of disease resistance in wheat

In the April-May and February-March 2014 issues of MOTHER EARTH NEWS, Stan Cox discusses some aspects of growing your own wheat: variety selection, growing methods, and processing of the harvest. One of the more important considerations in deciding which kind of seed to plant is the variation among wheat varieties in their reaction to fungi, bacteria, and viruses that can cause disease.

Wheat is plagued by a wider assortment of diseases than are most other grain crops. (North Dakota State University provides a good photographic compendium of wheat diseases.) The particular array of microbial threats varies from region to region and year to year, but few places escape completely. And when severe, diseases can wreck both the yield and the quality of harvested grain. Over the past century, wheat breeders have put at least as much effort into selecting for naturally-occurring genetic resistance to disease (no GMOs needed!) as they have into breeding for higher yield. In general, recently-developed varieties tend to have better resistance than do older ones; however, that is not always true, and almost every variety has one or more Achilles heels.

The risk-averse should simply avoid varieties that are especially susceptible to diseases that often strike wheat in their area. Many wheat growers plant a blend of two or more varieties. The logic of blending is that a mixture is more well-buffered against weather, diseases, and insects: when one variety has a bad year, others may take up the slack. But varieties included in the blend should be either all winter or all spring types with similar heights and harvest dates.

Guides to varieties, with disease-resistance ratings, are available for Eastern soft wheats, Great Plains hard winter wheats, and Northern hard red spring wheats, and there's also a guide for growing variety blends.

For wheat growers, it's a truism: Sow varieties that are resistant to prevalent diseases. But what if the wheat plant has to give up something for its resistance, so that it is less productive or its grain makes poorer bread? Would the resistance then be worth it?

Those are not questions that can be answered without controlled experiments. Simple observation can be deceptive. Close your eyes and think of any two wheat varieties; they will very likely differ in their geographical adaptation, yield potential, and reaction to the huge range diseases that infect wheat. If, for example, you happen to compare a specific rust-resistant variety with a susceptible variety, the resistant one might yield less or make poorer-quality bread than the susceptible one in a year without rust. (Depending on which ones you've picked, it could also yield more or make better bread.) However, that does not mean that resistance *causes* lower yield or quality. The two varieties differ not only in that rust gene, but also carry contrasting genes throughout their genomes. Any of those genetic differences could contribute to a difference in performance.

**Field Experiments**

Over the years, controlled field experiments in wheat and other crop species — all of them designed to answer the question, “Does the plant pay a price for resistance?”—have provided us with a clear answer: “Flip a coin.” A survey of these comparative studies, published in the 1990s, found that in exactly 44 out of 88 cases covering a wide range of species and genes,

resistant plants were less productive than susceptible ones in the absence of the relevant disease, insect, or herbicide. In the other 44 cases, there was no difference or, rarely, the resistant plants were more productive. The results of studies done since that time have continued to give widely varying answers to the questions of whether there's a yield effect and if so, how big it is.

In wheat as in other crops, some resistance genes reduce yield or quality while others do not. Many of wheat's genes for resistance have been transferred from related species. In the process, long stretches of DNA extending to either side of the resistance gene came along for the ride. Once in a wheat variety, some of those hitchhiking genes may affect other traits even if the resistance gene itself is benign. This has happened in the past with a chromosome segment from *Aegilops umbellulata* carrying the *Lr9* gene for leaf-rust resistance; it depressed yield by 5 to 14 percent. There are other genes such as *Fhb1,* which protects against Fusarium head blight, that appear to have brought no yield- or quality-reducing hitchhikers with them. Then there's a chromosome segment transferred from rye that carries genes for leaf, stem, and stripe rust resistance; it has had a *positive* effect on productivity but a negative impact on quality.

Sometimes the resistance gene itself appears to have a direct impact. The *Lr34* gene, which confers adult-plant resistance to leaf rust, originated within common wheat, but its yield-depressing effect is well known. But whether a yield reduction is caused directly by a resistance gene or indirectly by its bad neighbors, it is crucial to remember that these negative yield impacts have all been measured *when there is no disease present*. To the wheat grower, such an effect may be less important than the impact of the disease when it *does* strike.

For example, *Lr34* reduced yield of spring wheat by about 6 percent if there is no leaf rust infection. But when leaf rust infects the plant, it can cause 43 to 84 percent yield losses in varieties that are not protected by *Lr34* or other genes. At Kansas State University in the 1990s, my colleagues and I found that a leaf-rust gene transferred into wheat from the wild grass *Ae. tauschii* provided a 42 percent yield advantage under heavy leaf rust, while it had no yield-depressing effect when leaf rust was absent. And when fungi, bacteria, or viruses infect a wheat plant, they can decimate the bread-making or nutritional quality of the harvested grain. The rust diseases, for example, result in shriveled seed with poor gluten, while Fusarium head blight (a.k.a. “scab”) produces a dangerous toxin.

You never know at planting time which diseases will be the biggest threats over the coming season, but for diseases that are locally common, the possibility that a gene may have a modest negative effect on yield or quality in the absence of disease is probably less important than the risk of taking a much bigger hit to yield and quality that comes with sowing a susceptible variety.

And finally, there's no need to worry about at least one thing: wheat breeding for disease resistance has not made wheat’s gluten protiens hazardous to your health.