Zinc is important for crop yield and consumer health

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Farmers and their crop advisers should consider nutrients other than only nitrogen, phosphorus, and potassium when soil sampling to determine fertilizer rates for the 2021 growing season. Micronutrients, such as chloride, copper, iron, and zinc, are used in smaller amounts than the big three and insufficient soil levels are less often the cause of reduced production, making them easy to forget. However, they are critical for grain yields and consumer health.

Zinc in particular is important for human growth, strong immune systems, and even reducing violent moods. Children and adolescents are especially affected by zinc deficiency. The International Zinc Nutrition Consultative Group estimates at least 20% of the world's children suffer stunted growth due to zinc deficiency. Twenty-six countries have a mandatory minimum wheat grain zinc concentration standard (average 47 ppm); of these 26 countries, the Asian countries' average standard is 38 ppm (Global Fortification Data Exchange). Montana's grain could contribute to nourishing its consumers worldwide.

As grain yields per acre increase with newer crop varieties, the amount of micronutrients removed with each harvest increases. On average, a 45 bushel per acre crop of wheat removes 0.13 pound zinc, barley removes 0.06 pound, and canola 0.25 pound. If no micronutrients are added as conventional fertilizer, impurities in phosphorus fertilizer, or through the addition of manure, it is a matter of when, not if micronutrients become deficient. Of almost 13,000 Montana soil samples analyzed by AgVise laboratory in 2017, 32 percent contained below 0.5 ppm zinc, which is the critical level for most crops.

Biofortification is the use of fertilizer to increase grain nutrient content. Foliar zinc application has been found more effective than soil applications to boost grain zinc concentration. Smaller amounts of zinc are required to fortify the grain than increase yields.

A study at the Eastern Agricultural Research Center in Sidney, Montana, evaluated foliar zinc application on durum wheat on soils with 0.3 to 0.5 ppm zinc. One pound zinc per acre at heading increased grain zinc concentration by 17-47 percent and yields by 5 percent (Afshar et al. 2020). Two applications of 1 pound zinc per acre each, one at heading and a second at flowering increased grain zinc concentration by 35-93 percent and yields by 14 percent. To reliably bring grain zinc concentrations above 40 ppm required two zinc applications.

An additional benefit of foliar zinc is to decrease durum grain cadmium levels, an important measure for some export markets. A study at Eastern Agricultural Research Center (Eckhoff 2010) found 1 pound zinc per acre foliar at boot stage helped decrease grain cadmium concentrations to below 0.2 ppm, the current International standard of maximum cadmium levels in wheat (Codex Alimentarius).

In another study at Eastern Agricultural Research Center (Mohammed and Chen 2018) 1.5 pound zinc per acre was sprayed on pea as soon as there were enough leaves to catch the spray. At one site where soils were above critical levels, pea grain yield increased by 6 bu/acre with zinc but pea grain zinc concentration did not respond to foliar zinc. At the other site, where soils were below critical levels, one year saw no yield increase and small grain zinc concentrations increase with foliar zinc, but concentrations did not reach 40 ppm. In the second year, foliar zinc did not increase yields and all treatments, with or without foliar zinc, had equal grain zinc concentrations above 40 ppm. Therefore,

soil tests alone are not conclusive on whether there will be a response in yield or grain zinc concentration.

Visual deficiency symptoms (middle leaves show interveinal chlorosis similar to iron deficiency which is seen in youngest leaves; see *Plant Nutrient Functions and Deficiency and Toxicity Symptoms*), can indicate zinc deficiency. However, once symptoms are visible, yields may have already been compromised. Also, not all crops respond equally to zinc fertilization (Rigas Karamanos, personal communication; low response in alfalfa, oat, pea, wheat, canola, medium in barley, clover, sugar beet, and high in corn), even if soil test levels are low and plants show deficiency symptoms. Therefore, the best way to determine zinc need is through yield or grain concentration response in on-farm strip test trials.

A challenge with micronutrients is to get even distribution of a tiny amount of fertilizer. Plant available sources such as sulfates or chelated fertilizers can be broadcast and incorporated in the spring or applied foliar. Note that glyphosate and metal micronutrients should not be combined in spray, as they can inactivate each other. Oxides need to convert in the soil before being plant available and should be applied in fall. Seed-placed or subsurface band is not recommended due to high localized concentrations leading to toxicity. Manure is another option to provide micronutrients.

Micronutrient fertilizers should be used judiciously. The net economic return with one zinc application to wheat was negative $0.40 per acre, with the double application the net return was $5.25 per acre (Afshar et al. 2020). Price incentives for grain with higher zinc levels would help encourage farmers to grow more nourishing grains.

Contact Clain Jones at clainj@montana.edu, 406-994-6076, with questions about this or other soil fertility topics. This article is available online at https://landresources.montana.edu/soilfertility/timelytopics/zn_wheatgrain.html.

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