

Zinc Fertilizers. Is there a Difference?

Plant availability of zinc depends on water solubility of fertilizers.

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Zinc (Zn) is one of the micronutrients required for plant growth and the most common micronutrient that is deficient in Colorado soils. One of the main reasons for this is that our soils are generally alkaline in pH and contain free lime (CaCO_3), which ties up the Zn in unavailable forms. The Zn sensitive crops grown in Colorado include corn, sorghum, sudan, sorghum X sudan hybrids, dry beans and potatoes. These crops respond to Zn fertilization if the soil Zn levels are low. The next logical question is "Are my soils low in available Zn?" - only a soil test can tell you this. All soil testing laboratories operating in this region can perform this test for you. So, I get a soil test performed, and sure enough, the soil tests low in Zn! What's next? Well, the application of a Zn fertilizer, of course. The question we would like to address is "Are all Zn fertilizers equally effective in correcting Zn deficiencies?" In the market place, disagreement exists regarding the effectiveness of the many Zn fertilizers that are being sold.

Some people question the importance of water solubility of a granular Zn fertilizer and its relationship to Zn availability to plants. What is water solubility and why should it matter? Water solubility indicates how much of the fertilizer will dissolve in water. Why does it matter? Most nutrients are taken up from the soil solution by the plant; therefore, if a fertilizer will not dissolve in the soil solution, it will probably not be an effective fertilizer.

Solubility is related to the process used in fertilizer manufacturing and the primary product used as a Zn source. Many Zn fertilizers in the market place are manufactured from industrial by-products such as zinc oxide (ZnO). Unfortunately, ZnO is not water soluble and not an effective Zn fertilizer on our alkaline soils. To prepare granular Zn fertilizer from ZnO , it is reacted with sulfuric acid (H_2SO_4) to improve solubility and promote granulation. The final product will be a mixture of ZnO and zinc sulfate (ZnSO_4). Zinc sulfate is essentially 100% water soluble and a good Zn source for plants. The more acid with which ZnO is reacted, the more ZnSO_4 that is formed, and the higher the water solubility of the final fertilizer material. Fertilizers that are mixtures of ZnO and ZnSO_4 are called Zn oxysulfates.

We conducted some studies to determine if the percent water solubility of a granular Zn fertilizer is a measure of its ability to supply Zn to the plant. Corn plants were grown in the greenhouse on a Zn-deficient soil. Six Zn fertilizer materials were evaluated ranging from 99.9% to 0.7% water solubility. The fertilizers included ZnSO₄ and five Zn oxysulfate fertilizers ranging in water solubility from 98.3 to 0.7% water solubility: Zn20 (98.3%), Zn27 (66.4%), Zn40 (26.5%), ZnOxS (11%), and ZnOS (0.7%). The first number is the total Zn content of the fertilizer and the number in parenthesis is the water solubility. The ZnSO₄ contains 36% Zn and is about 100% water soluble. We use ZnSO₄ as our reference to which we compare all other fertilizers. Fertilizer rates used were equivalent to 0 (control), 5, 10 and 20 lb Zn/A. Plants were harvested about 6 weeks after emergence. Previous work has shown that there is no need to grow corn plants to maturity to evaluate the effectiveness of different fertilizer sources, as results will be similar to those during early growth stages. Plant growth (dry matter production) and Zn uptake were measured. We only present the plant growth data here.

Zinc-deficiency symptoms were observed on the corn plants grown with the two fertilizers with the lowest water solubility, ZnOxS (11%) and ZnOS (0.7%). These symptoms were evident as early as 5 days after emergence. Pronounced bands of chlorosis appeared on the leaves, starting near the leaf whorl and extending up the leaf. These bands turned white with time. As plant growth progressed, Zn-deficiency symptoms also occurred with the Zn40 (26.5%). Plants fertilized with these three materials were stunted in growth. Slight Zn deficiencies were also observed with Zn27 (66.4%), but the reduction in plant growth was very small.

The dry matter production for the various Zn fertilizers is shown in Figure 1. Based on the plant growth response, three groups of Zn fertilizer materials were identified: (i) ZnOS (0.7%) resulted in no significant growth increase with Zn application (Fig. 1), (ii) Zn40 (26.5%) and ZnOxS (11%) resulted in a small increase in corn growth as Zn rate increased and (iii) ZnSO₄ (99.9%), Zn20 (98.3%), and Zn27 (66.4%) all increased growth substantially. The very low agronomic effectiveness of ZnOS (0.7%), ZnOxS (11%), and Zn40 (26.5%) is related to their lower water solubilities and the inability of these fertilizers to release Zn to the plant. The application of high rates of Zn from fertilizers containing low water soluble Zn did not satisfy the plant's needs.

A Zn application rate of 5 lb/A was sufficient to maximize dry matter production when Zn was applied as Zn₂₀ (98.3%), Zn₂₇ (66.4%), and ZnSO₄ (99.9%). In fact, no significant differences were observed between 5 as compared to 10 and 20 lb Zn/A. In contrast, Zn₄₀ (26.5%) required 20 lb/A to obtain optimum dry matter production (Fig. 1). This clearly shows that water solubility of granular Zn fertilizer was related to availability.

CONCLUSIONS

The agronomic effectiveness of the six granular Zn fertilizers studied decreased as the percent water-soluble Zn decreased: ZnSO₄ (99.9%) > Zn₂₀ (98.3%) > Zn₂₇ (66.4%) > Zn₄₀ (26.5%) > ZnOxS (11%) > ZnOS (0.7%). High correlations were found between water solubility of Zn in the fertilizer material and plant response. We conclude that granular Zn fertilizers should have water-soluble Zn levels of at least 50% to be effective in supplying adequate Zn levels for the current crop. Knowing the total Zn content of a fertilizer is not enough to determine which fertilizer you should use. You need to know the degree of water solubility of granular Zn fertilizers before you purchase them. Ask your fertilizer dealer for this information and if the water solubility is not at least 50%, use a different material that satisfies this requirement.

Do these greenhouse results apply to field conditions?

Many people ask this question. Under some circumstances the answer is NO. However, when a greenhouse study is used to evaluate the availability of micronutrients to plants the results are directly applicable to field conditions. In fact, many researchers have reported that “if a micronutrient doesn't do the job in the greenhouse, it won't work in the field.” The reason is that in a greenhouse study plant roots are confined to a small volume as contrasted to a very large rooting volume that occurs in the field. This results in a much higher density of roots in the soil in the greenhouse and a greater chance for the plant's roots to come in contact with the fertilizer granule, or its diffusion zone. Consequently, this is an advantage to fertilizers that have a low water solubility. So, if a fertilizer doesn't work in the greenhouse, it won't work under field conditions!

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