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Is Zinc Fertilizer Water Solubility Important For Long-term Zinc Efficiency?

Knowing total zinc content of a fertilizer is not enough on which to evaluate the value of a specific fertilizer.

***Summary:** Our research has demonstrated the longer term effectiveness of water- soluble and non-water-soluble zinc (Zn) fractions found in many common Zn fertilizers. Clearly, water-soluble Zn is much more effective in increasing Zn DTPA soil tests than was the non-water-soluble fraction of these materials. We found that about 5.0 lbs/A of water-soluble Zn is required to increase DTPA Zn soil test one part per million while it requires about three times as much non-water-soluble Zn to effect the same change. Knowing the total Zn content of a fertilizer is not enough information on which to base purchasing decisions—it is important to know the water-soluble Zn content as well.*

Zinc has long been recognized as an essential crop nutrient that often limits crop growth, development, and profitability. While Zn fertilizer application has been common for many years, there are still questions concerning the importance of the water solubility of various Zn fertilizer products in providing agronomic response. Past research has generally indicated that the water-soluble fraction of total Zn in fertilizer products should be greater than 40-60 percent in order to correct any Zn nutritional problems in the current crop. For example, a greenhouse study conducted at Colorado State University resulted in high correlation between percent water solubility and both dry matter production and Zn uptake by corn grown immediately after Zn application. It also concluded that Zn fertilizers should have a minimum of 50 percent of the total Zn in a water-soluble form

Zinc sulfate has traditionally been the product of choice for many fluid Zn fertilizers as well as dry fertilizer applications and is 100 percent water soluble. Zinc oxide contains essentially none of the Zn in a water-soluble form and has generally performed poorly unless it is very finely ground and applied at high rates. There are, however, many Zn fertilizer products in the marketplace that contain various proportions of the total Zn present in a water-soluble form. Most of these products are referred to as oxysulfates and are generally produced by acidulating by-product Zn oxide with sulfuric acid. They generally contain varying mixtures of Zn sulfate and Zn oxide. In general, the greater the acidulation of Zn oxide with sulfuric acid, the greater the water-soluble Zn content of the resulting product.

While there is general agreement on the importance of water-soluble Zn for optimum crop response in the year of application, questions remain about the longer term residual benefit of products containing significant percentages of non-water-soluble Zn. Will application of Zn fertilizers containing significant portions of total Zn in a non-water- soluble form provide longer term residual responses? Will the oxysulfates be as effective in increasing DTPA Zn soil test levels as Zn fertilizers containing all of the Zn in a water-soluble form?

To answer these questions, studies were established in 2003 to evaluate the long-term efficacy of Zn fertilizers containing non-water-soluble Zn. Specifically, the objective of these studies was to evaluate the effect of Zn fertilizers containing varying percentages of non-water-soluble Zn on longer term DTPA Zn soil test values. Neither crop yield response nor Zn uptake was measured in any of these studies.

Individual plots were sampled to a depth of six inches and analyzed for pH, soil organic matter content, excess lime, and DTPA extractable Zn (Table 1). Soils ranged from slightly acidic to high pH/calcareous while cropping systems included dryland/no-till, dryland/minimum-till, and irrigated/conventional-till. A fertilizer derived from Zn sulfate and two Zn oxysulfate fertilizers with varying water solubility percentages (15-96%) were included in order to evaluate a wide range of water solubility (Table 2). Each Zn fertilizer was broadcast at rates equivalent to 5 and 15/lbs/A of Zn at the beginning of each study. No additional Zn was applied for the duration of the studies. Individual plots were resampled about one year after initial Zn application and again after two years. At each sampling and for each location, the change in Zn soil test was determined by subtracting the individual check plot soil test value for a given replication from the individual treatment soil test value for that same replication. All plots were carefully sampled to a depth of six inches.

DTPA Zn Soil Test Changes

Despite differences in soils and cropping systems, Zn application effects on changes in DTPA Zn soil test were similar for each location and for both years (Tables 3 and 4). No significant interactions were measured. However, while the Ford location tended to have smaller changes in soil test values than the other locations, there is a logical reason for this trend. The Ford location had the most aggressive and deepest tillage during the two years of this study. Chiseling and disking deeper than six inches (8-inch deep tillage at Ford) would have mixed the applied Zn with a greater volume of soil than at any of the other sites and likely result in less change in soil test values. The Ness and Dodge sites were never tilled deeper than four inches while the Thomas site was in no-till production. While the Ford location was also the only site with significant excess lime, which might possibly affect soil test change, the greater depth of tillage was more likely the reason for slightly less soil test change at this location.

Since there were no significant differences between years or among locations, all four studies were combined in order to summarize the information. There were large differences in soil test change among Zn fertilizer sources and Zn with application rate. Changes in soil test values over the two years of this study were highly correlated

Table 1. Selected characteristics of locations used for residual Zn soil test studies.

Location	Production system	Soil pH	Free lime	Organic Matter	DTPA Zn (ppm
Thomas	Dryland/No-till	5.4-6.5	None	1.7%	0.6
Ness	Dryland/Minimum-till	6.1-6.6	None	2.2%	0.5
Dodge	Dryland/Minimum till	6.3-8.0	None	2.7%	0.6
Ford	Irr./Conventional-till	7.9-8.3	Moderate	2.0%	2.0

Table 2. Total and water-soluble Zn contents of three Zn sources used.

	Product Zn content (%)		Water-soluble Zn
Zn Form	Total Zn	Water Soluble Zn	(% of Total Zn)
Zn Oxysulfate	27.5	4.2	15%
Zn Oxysulfate	33.4	16.6	50%
Zn Sulfate	17.1	16.5	96%

Table 3. Effect of Zn fertilizer water solubility on DTPA Zn soil test
(Four-location average)

			DTPA Zn change (ppm)	
Zn source	% Water-soluble	Zn Rate	2004	2005
Check	---	0	0.0	0.0
Oxysulfate	15	5	0.4	0.2
Oxysulfate	15	15	1.3	1.4
Oxysulfate	50	5	0.7	0.6
Oxysulfate	50	15	2.2	2.0
Zinc Sulfate	96	5	1.1	0.8
Zinc Sulfate	96	15	3.2	2.5
		Probability > f	<0.01	<0.01
		LSD (0.05)	0.8	0.6

Table 4. Effect of Zn fertilizer water solubility on DTPA Zn soil test
(Average of 2004 and 2005 resamplings)

		Change in DTPA soil test Zn (ppm)				
% Water-soluble	Zn rate	Thomas	Ness	Dodge	Ford	Average
---	0	0.0	0.0	0.0	0.0	0.0
15	5	0.2	0.2	0.4	0.3	0.3
15	15	1.9	1.5	1.0	1.0	1.4
50	5	0.7	0.5	0.9	0.4	0.6
50	15	2.5	2.1	2.0	1.7	2.1
96	5	0.9	0.8	0.9	1.4	1.0
96	15	3.7	2.9	2.9	2.0	2.9
	Probability > f	<0.01	<0.01	<0.01	<0.01	<0.01
	LSD (0.05)	0.5	0.5	0.8	0.9	0.5

with the water-soluble Zn level of the specific Zn fertilizer used. Likewise, the change in Zn soil test level was also directly related to the Zn application rate. Figure 1 presents the interaction between water-soluble Zn percentage of the Zn fertilizer and Zn application rate. At any given Zn application rate, the higher the water-soluble percentage of the material, the greater the effected change in DTPA Zn soil test.

While the non-water-soluble Zn present in Zn oxysulfate does have some effect on long-term DTPA Zn soil tests, the water-soluble Zn fraction of these materials has a much greater effect. In order to increase DTPA Zn soil tests one part per million, about 5.0 lbs/A of broadcast water-soluble Zn was required. At the same time, it took 14.6 lbs/A of non-soluble Zn to effect a one-part-per-million DTPA soil test change. Stated another way, the water-soluble portion of Zn oxysulfate and Zn sulfate is about three times more effective in building DTPA Zn soil test values than the non-water-soluble fraction (Figure 1).

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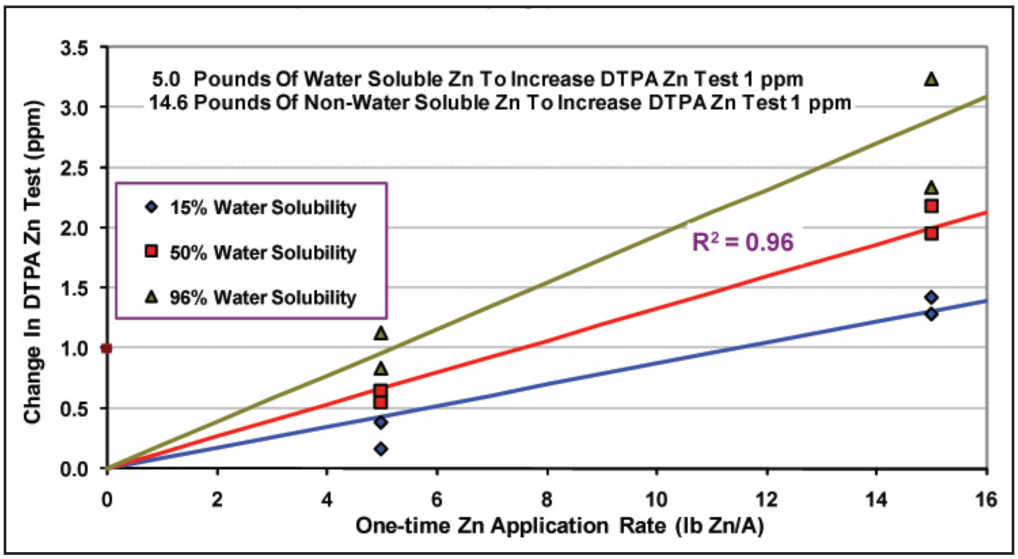

Figure 1. Effect of various Zn sources on DTPA Zn soil test.