EFFECT OF ZINC FERTILIZERS OF VARYING WATER SOLUBILITY ON LONG TERM DTPA-ZN SOIL TESTS

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INTRODUCTION

There are many zinc (Zn) fertilizer products on the market and these products often vary considerably in water solubility. In general, there are two main types of granular zinc products currently being marketed - zinc sulfate and various zinc oxysulfates. While the zinc in zinc sulfate is generally all water soluble, zinc oxysulfates vary considerably in water solubility. Zinc oxysulfates are typically produced by reacting sulfuric acid with various by-product zinc oxides. Zinc oxide is very low in water solubility. The addition of sulfuric acid to zinc oxide by-products promotes granulation during the manufacturing process and increases the water solubility of the final product. In general, the greater the amount of sulfuric acid included during manufacturing, the greater the water solubility of the final product, but, the higher the manufacturing cost.

Previous greenhouse work by Amrani, et. al (1999) indicated that corn Zn uptake and crop response were directly related to the water soluble Zn content of the product used. They concluded that greater than 50% water solubility is necessary for efficient crop growth and development immediately after application. Since broadcast Zn applications of 5 to 20 pounds of Zn metal per acre are intended to increase soil test values to a longer term, non-limiting soil test range, there remains the question of long term efficacy of zinc products of varying water solubility for increasing DTPA-Zn soil test values.

With this information in mind, the objective of this work was to 1) evaluate the effect of the water soluble and non-water soluble fractions of various granular zinc fertilizer products on increasing DTPA-Zn soil test values and 2) estimate the amount of Zn required to increase DTPA-Zn soil test values 1 part per million.

MATERIALS AND METHODS

Four locations distributed across a broad section of western Kansas were selected for multi-year studies. Dryland locations included Thomas, Ness and Ford County (near Dodge City). Additionally, an irrigated site was established in Ford county (near Ford). Soil samples (0-6" depth) were collected from each individual plot prior to fertilizer Zn application. For each sampling, about 10-12 individual soil cores were collected from each plot, combined into a composite sample and the sample then submitted to the KSU laboratory for analysis.

The fraction of the total Zn in the product that was water soluble was determined for several zinc fertilizer products by the Kansas State University research laboratory before the study was initiated using the AOAC method. Zinc products selected for inclusion in the studies included zinc sulfate (96% water soluble) and two zinc oxysulfate materials with water solubility's of 15% and 50% water soluble zinc.

A randomized, complete block design with four replications was used at each location. All products were broadcast applied at rates of 5 and 15 pounds of total zinc per acre. In addition to individual plot sampling prior to the establishment of the studies in January 2003, the two Ford county locations were sampled 12 months later in January of 2004. Because of severe drought, the Ness and Thomas county locations could not be sampled until June of 2004. All locations were again sampled in January 2005, two years after study establishment. For each sampling, each individual Zn treatment plot was compared to the corresponding check plot DTPA-Zn soil test value for each replication. General characteristics of each location are presented in Table 1.

Table 1. General Site Characteristics Of Four Locations Utilized

Location		Tillage System	Soil Acidity	Free Lime
Thomas Co.	Dryland	No-Till	5.4 – 6.5	None
Ness Co.	Dryland	Minimum Till	6.1 – 6.6	None
Ford Co. (Dodge)	Dryland	Minimum Till	6.3 – 8.0	None
Ford Co. (Ford)	Irrigated	Reduced Till	7.9 – 8.3	Slight - Moderate

RESULTS AND DISCUSSION

It appears that the efficacy of zinc fertilizer products effecting DTPA Zn soil test change is directly related to amount of water soluble zinc in the product. (Tables 2-6). Highly significant differences due to the specific zinc product used and the rate at which it was applied were recorded. While minor differences among locations were observed, there was not a location x zinc product or location x Zn rate interaction noted. In general, DTPA Zn soil tests changed the most at the Thomas county location and least at the irrigated Ford county location. Interestingly, no tillage has occurred at the Thomas county location while the irrigated Ford county location has undergone the deepest and most frequent tillage of all the sites. It is likely that much of the difference among locations can be explained by the amount of soil affected (soil depth) by the initial zinc application.

Averaged across locations, it is clear that the greater the zinc product water solubility, the greater the effect on resulting DTPA-Zn soil test values. Further analysis reveals that the change in DTPA Zn soil test is highly correlated to the amount of water soluble and water insoluble zinc applied (Figure 1). It appears that about 5 pounds of water soluble zinc is required to increase DTPA soil tests 1 ppm, while about 15 pounds of non-water soluble zinc is required to increase DTPA soil tests 1 part per million.

REFERENCES

Amrani, M., D.G. Westfall, and G.A. Peterson. 1999. Influence of water solubility of granular zinc fertilizers on plant uptake and growth. J. Plant Nutr. 22:1815–1827.

Table 2. Effect Of Zinc Fertilizer Water Solubility On DTPA Zn Soil Test Change Ness County, 2004 and 2005

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test Change 2004	DTPA Zn Soil Test Change 2005
	Lb/a	%	relative to check (ppm)	
Product A	5	15	0.28	0.20
Product A	15	15	1.62	1.40
Product B	5	50	0.52	0.45
Product B	15	50	1.98	2.20
Product C	5	96	0.80	0.72
Product C	15	96	2.92	2.78
		Significance Level	< 0.01	< 0.01

Table 3. Effect Of Zinc Fertilizer Water Solubility On DTPA Zn Soil Test Change Thomas County., 2004 and 2005

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test Change 2004	DTPA Zn Soil Test Change 2005
	Lb/a	%	relative to check (ppm)	
Product A	5	15	0.08	0.22
Product A	15	15	2.25	1.48
Product B	5	50	1.00	0.32
Product B	15	50	2.72	2.18
Product C	5	96	1.12	0.62
Product C	15	96	3.38	3.95
		Significance Level	0.08	0.02

Table 4. Effect Of Zinc Fertilizer Water Solubility On DTPA Zn Soil Test Change Dodge City, 2004 and 2005

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test Change Plot 2004	DTPA Zn Soil Test Change Plot 2005
	Lb/a	%	relative to check (ppm)	
Product A	5	15	0.70	0.18
Product A	15	15	1.02	1.04
Product B	5	50	1.28	0.54
Product B	15	50	2.50	1.58
Product C	5	96	1.12	0.76
Product C	15	96	3.52	2.34
		Significance Level	< 0.01	< 0.01

Table 5. Effect Of Zinc Fertilizer Water Solubility On DTPA Zn Soil Test Change Ford, 2004 and 2005

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test Change Relative To Check Plot 2004	DTPA Zn Soil Test Change Relative To Check Plot 2005
	Lb/a	%	relative to check (ppm)	
Product A	5	15	0.35	0.22
Product A	15	15	1.00	0.98
Product B	5	50	0.48	0.25
Product B	15	50	2.02	1.30
Product C	5	96	1.98	0.72
Product C	15	96	2.56	1.52
		Significance Level	0.05	< 0.01

Table 6. Effect Of Zinc Fertilizer Water Solubility On DTPA Zn Soil Test Change All Locations Combined, 2004 and 2005

Zn Product	Zn Rate	Water Soluble Zn	DTPA Zn Soil Test Change Relative To Check Plot 2004	DTPA Zn Soil Test Change Relative To Check Plot 2005
	Lb/a	%	relative to check (ppm)	
Product A	5	15	0.38	0.17
Product A	15	15	1.28	1.42
Product B	5	50	0.65	0.56
Product B	15	50	2.17	1.95
Product C	5	96	1.13	0.83
Product C	15	96	3.24	2.50
		Significance Level	< 0.01	< 0.01

Figure. 1 Effect Of Various Zinc Sources On DTPA Zn Soil Test
(2003 to 2005)