AMMONIUM THIOSULFATE AS A UREASE INHIBITOR

A SUGGESTED MECHANISM

R. J. Goos[1]

Introduction

A great deal of interest, and some controversy, has been generated by my observations (Goos, 1985a; Goos, 1985b; Fairlie and Goos, 1986) that ammonium thiosulfate (ATS, 12-0-0-265) can inhibit soil urease activity when mixed with fertilizers such as urea-ammonium nitrate (UAN). Preliminary field research (Gascho and Burton, 1987; Fox and Piekielek, 1987; Lamond et al. 1986) has shown some increase in crop yields or N uptake by adding ATS to surface-applied UAN. However, the use of ATS as a urease inhibitor is still controversial. For example, Bremner et al. (1986) concluded that ATS was of "no practical value" as a urease inhibitor.

It has been my opinion that the full benefits of the use of ATS as a urease inhibitor would not be appreciated until its basic mechanism was understood. It was originally speculated that ATS acts as a general metabolic inhibitor.

ATS is unique amongst urease inhibitors, in that it has no effect on the activity of purified urease in the absence of soil (Goos, 1985a). Powerful reducing agents (eg. hydroquinone) can inhibit urease by chemically altering the enzyme. ATS is not powerful enough of a reducing agent for this effect.

Proposed Theory

Since ATS does not directly affect the urease enzyme, an indirect mechanism is proposed. Thiosulfate reacts rapidly and abiotically with soil, forming tetrathionate and liberating Fe^{2+} and Mn^{2+}:

$$2\ Fe(OH)_3 + 2S_2O_3^{=} + 6H^+ \longrightarrow 2Fe^{2+} + S_4O_6^{=} + 6H_2O$$

$$MnO_2 + 2S_2O_3^{=} + 4H^+ \longrightarrow Mn^{2+} + S_4O_6^{=} + 2H_2O$$

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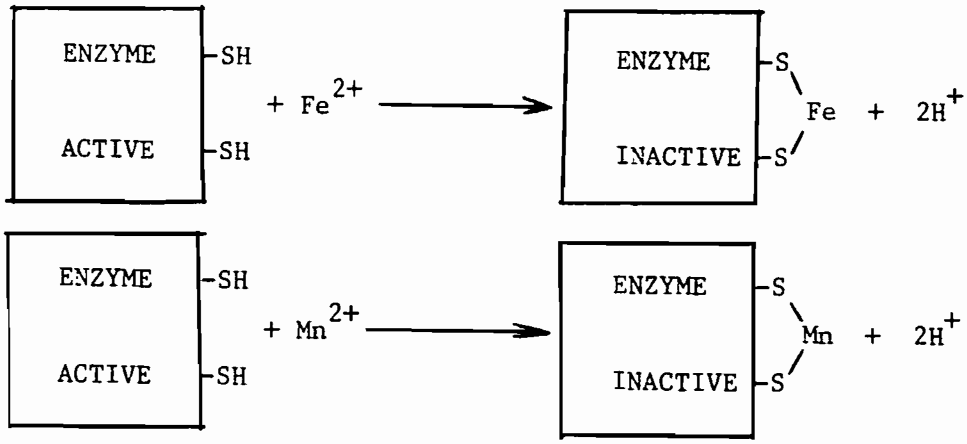
The urease enzyme has 4-8 sulhydryl groups at its catalytic center. Ions such as Fe^{2+} and Mn^{2+} inactivate urease by binding to these sulfhydryl groups (Shaw, 1954):



This theory, if substantiated, would explain why ATS has no effect on purified urease, and why the benefits of ATS as a urease inhibitor are strengthened by "dribble" application.

Experimental Evidence

The following experiment[2] illustrates, to my satisfaction, that the proposed theory is correct. A Fargo silty clay was allowed to react overnight with either a Na_2SO_4 or $Na_2S_2O_3$ solution. The next day the original SO_4 or S_2O_3 treatment was removed by repeated extraction and centerfugation. The soil was then tested for either urease activity or extractable Fe and Mn. A portion of the results of this experiment is summarized in Table 1.

Table 1. Effect of salt pretreatment on urease activity and extractable iron and manganese in a Fargo silty clay.

Salt Pretreatment‡	Urease Activity	0.1 M HCl Extractable Fe	0.1 M HCl Extractable Mn
	mg NH_4-N kg^{-1} h^{-1}	--mg kg^{-1}--	
Na_2SO_4	121	4	104
$Na_2S_2O_3$	73	14	178
SE+	1	1	<1

‡ The original pretreatment was removed by repeated extraction.
\+ Standard Error

[2] The full details of this experiment are described in a paper currently in review to the Soil Science Society of America Journal.

The urease activity of the soil was inhibited by 40% even after the original thiosulfate treatment had been removed by repeated extraction. There were significant increases in extractable Fe and Mn. Thus, the proposed theory would explain this effect of thiosulfate on soil urease.

There are several implications of this research. Most importantly, will ATS be effective in suppressing the urease activity associated with crop residues? Crop residues, if well-colonized with microorganisms, have a very high urease activity (Goos, 1985c), and a much lower Fe and Mn content than soil.

In any case, ATS remains as the only urease inhibitor which is: 1) compatable with common liquid fertilizers, 2) inexpensive, and 3) commercially available. More research into the potential of ATS as a urease inhibitor is encouraged.

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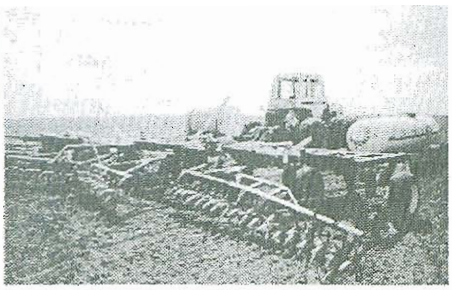
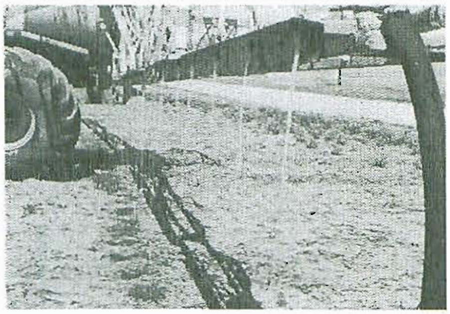

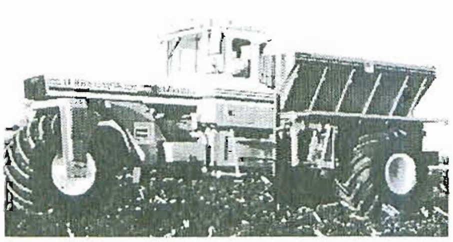
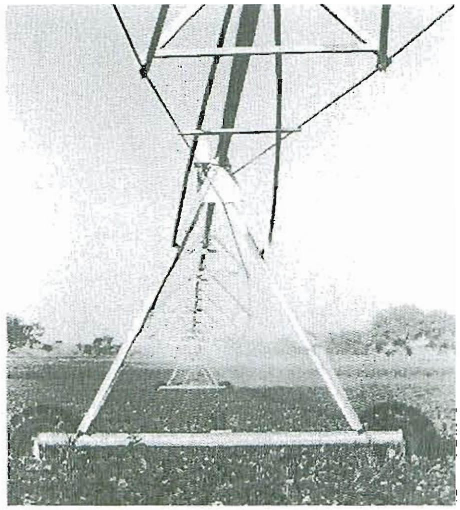

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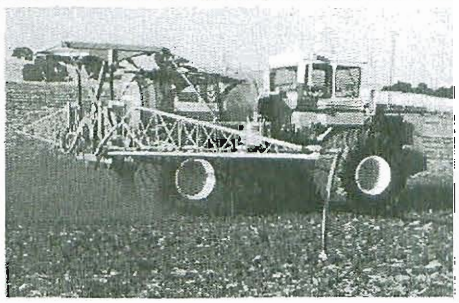

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