Evaluation of ammonium thiosulfate as a soil urease inhibitor

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Abstract

Interest in use of ammonium thiosulfate (ATS) in conjunction with urea as a fertilizer has been stimulated by recent reports that this compound retards hydrolysis of urea by soil urease and thereby reduces volatilization of urea N as ammonia from soils fertilized with urea. We evaluated ATS as a soil urease inhibitor by studying its effects on urea hydrolysis, seed germination, and early seedling growth in soil. We found that ATS significantly retarded urea hydrolysis only when applied at rates as high as 2,500 or 5,000 μg g⁻¹ soil, whereas N-(n-butyl) thiophosphoric triamide (NBPT) (a patented inhibitor of urea hydrolysis in soil) caused substantial retardation of urea hydrolysis when applied at rates as low as 1 μg g⁻¹ soil. We also found that ATS had an adverse effect on germination of corn or wheat seeds in soil when applied at the rate of 2,500 or 5,000 μg g⁻¹ soil and caused a dramatic reduction of early seedling growth of corn or wheat when applied at the rate of 1,000, 2,500, or 5,000 μg g⁻¹ soil. These findings indicate that ATS has little, if any, potential value for retarding hydrolysis of urea fertilizer in soil.

Introduction

Interest in ammonium thiosulfate (ATS) as a nitrogen and sulfur fertilizer has been stimulated by reports by Goos and coworkers [6, 8–11] that this compound is an effective soil nitrification and urease inhibitor and merits consideration as a fertilizer amendment for inhibition of ammonia oxidation and hydrolysis of urea fertilizer in soil. We evaluated ATS as a fertilizer amendment for inhibition of nitrification in soil by studying the effects of different amounts of ATS on oxidation of ammonium in soils treated with ammonium sulfate [3]. We found that ATS inhibited nitrification only when added to soils at high rates (≥ 250 μg thiosulfate g⁻¹ soil) and that, when added at such rates, it caused accumulation of potentially toxic amounts of nitrite. Other workers have also observed marked accumulation of nitrite in soils treated with ATS [12] and have been unable to demonstrate significant inhibition of nitrification by ATS under field conditions [10,11].

Although it is now generally agreed that ATS has no potential value as a soil nitrification inhibitor, there remains considerable interest in the use of this compound for retarding hydrolysis of urea fertilizer in soil [16]. The purpose of the work reported here was to assess the potential value of ATS for retarding hydrolysis of urea fertilizer in soil by comparing its ability to retard urea hydrolysis with that of N-(n-butyl) thiophosphoric triamide (NBPT) (a patented inhibitor of urea hydrolysis in soil) and by studying the effects of different amounts of ATS on seed germination and early seedling growth in soil.
Materials and methods

The soils used (Table 1) were surface (0–15 cm) samples of Iowa soils selected to obtain a range in properties. Before use, each sample was air-dried and crushed to pass through a 2-mm screen. In the analyses reported in Table 1, pH was determined with a glass electrode (soil:water ratio, 1:2.5), and total N was determined by a semimicro-Kjeldahl procedure [2]. Organic C was determined as described by Mebius [14], and CaCO₃ equivalent was calculated from inorganic C determined as described by Bundy and Bremner [4]. Particle-size analysis was performed as described by Genrich and Bremner [7].

Ammonium thiosulfate (ATS) was obtained from Fluka Chemical Co., Hauppauge, NY. The effect of ATS on urea hydrolysis in soils was compared with that of N-(n-butyl) thiophosphoric triamide (NBPT), a patented soil urease inhibitor. NBPT was obtained from Allied Corporation, Solvay, NY.

Unless otherwise specified, the procedure used to study the effects of the test compounds on urea hydrolysis in soils was as follows. Five-gram samples of air-dried soils were placed in 65-mL glass bottles and treated with 2 mL of water containing 10 mg of urea or with 2 mL of water containing 10 mg of urea and various amounts of the test compound. The bottles were stoppered and placed in an incubator at 20°C. After 3 and 10 days, triplicate bottles were removed from the incubator, and urea in the incubated soil samples was extracted with 2M KCl containing 5 μg mL⁻¹ of phenylmercuric acetate as described by Douglas and Bremner [5] and determined by the colorimetric method described by Mulvaney and Bremner [15]. Percentage inhibition of urea hydrolysis by the test compound was calculated from \((C-T)/C \times 100\), where \(T\) = amount of urea hydrolyzed in the soil sample treated with the test compound, and \(C\) = amount of urea hydrolyzed in the control (no test compound added).

The following procedure, based on the rules for seed testing published by the Association of Official Seed Analysts [1], was used to determine the effects of the test compounds on seed germination in soil. Air-dried soil (40 g) was placed in a 15 mm × 100 mm Petri dish (Fisher Scientific, Pittsburgh, PA) and moistened with 10 mL of water (control) or with 10 mL of water containing the test compound. Twenty-five seeds of corn or 100 seeds of wheat were placed on the soil, and the Petri dish was covered with a lid and kept in the dark for seven days in an incubator maintained at 20°C. The number of seeds germinated was then counted and calculated as a percentage of the number of seeds sown. The criterion for germination of the seeds studied was the emergence of a rooting structure and a coleoptile that were longer than the seed. All germination tests reported were performed in quadruplicate.

To determine the effects of the test compounds on seedling growth, 20 wheat seeds were placed on 40 g of air-dried soil in a 15 mm × 60 mm Petri dish and the soil was moistened with 10 mL of water (control) or with 10 mL of water containing the test compound. The Petri dish was then covered with a lid and placed in an incubator maintained at 20°C. After seven days, the roots and shoots from germinated seeds were measured. All tests reported were performed in triplicate.