Chapter 7. Effect of Soil Urease Inhibitors on Germination, Growth, and Yield of Plants

7.1. EFFECT OF UREASE INHIBITORS ON MAIZE (Zea mays)

7.1.1. Effect of Alkali Metal and Alkaline Earth Metal Salts

Based on the results of a laboratory experiment in which KCl addition to urea reduced the volatile N losses as ammonia [for example combination of 1 part of urea with 1 part of KCl (by weight) applied in solution on samples of a loamy sand soil reduced the NH₃ losses from 24.0 to 4.5%], Rappaport and Axley (1984) initiated field experiments on 3 by 15 m plots installed on a silt loam soil in Maryland. The solution containing only urea (8.4 g N/m²) and that containing both urea and KCl (at urea/KCl weight ratio of 1:1) were applied 2 days after planting of maize. KCl added with urea significantly (p=0.05) increased maize yield over urea alone from 768 to 881 g/m². But when KCl was added 10 days after urea addition, no yield increase was recorded.

Fox et al. (1986) conducted 1-year (1983) field experiments on a silt loam soil (pH 6.1-6.5) in central Pennsylvania for evaluating the effect of urea-KCl on no-till maize yields and N uptakes. The solid urea-KCl used contained 300 g N and 166 g K/kg. Urea alone and urea-KCl were surface-applied, at planting, at three rates of N: 67, 134, and 202 kg/ha. The grain yields and N uptakes by plants were not significantly different between the urea-only and the urea-KCl treatments at any fertilizer rate.

The field experiments conducted by Bundy and Oberle (1988) for studying several N fertilizers, including urea-CaCl₂ and urea-KCl solution and urea prills surface-applied at rates of 56 and 112 kg N/ha on silty loam soils cultivated with maize at Arlington and Lancaster (Wisconsin), are referred to on page 28. While the volatilized ammonia was measured at the higher N rate only, the grain yield and N uptake by plants were evaluated at both N rates. At the higher N rate, significant differences among the three N fertilizers that can be attributed to NH₃ volatilization were observed only at Lancaster. At this location, also at the lower N rate, grain yield and N uptake were significantly higher in the urea-CaCl₂ than in the urea treatment. In contrast, grain yield and N uptake were not significantly different in the urea-KCl and urea treatments.

MacKenzie et al. (1988) studied the effect of urea-KCl on the silage maize yield in 4-year (1981-1984) field experiments on an eastern Canadian clay loam soil (pH 6). Urea was applied at rates of 0, 90, and 180 kg N/ha for each year. Rates of added KCl were 0, 60, and 120 kg K₂O/ha for the first 2 years, and 0, 120, and 240 kg K₂O/ha for the last 2 years. Both urea and KCl were surface-applied at planting. Except in 1981, when the highest dry matter yield of maize plants (11.3 t/ha) was registered in the 180 kg N + 60 kg K₂O/ha rates, in the next 3 years the yields were highest (15.6, 11.3, and 17.0 t/ha, respectively) at the highest N + K₂O rates. The mean values of yields were lower in the urea-only than in the urea-KCl treatments in each year.

7.1.2. Effect of Fluorides

In the pot experiments of Gaponyuk and Kuznetsova (1984), urease activity was not inhibited in soil samples treated with NaF at rates of 0.1-3 g F/kg soil (see page 34), but root growth of maize seedlings was strongly reduced at rates ≥ 0.5 g F/kg soil.

S. Kiss et al., Improving Efficiency of Urea Fertilizers by Inhibition of Soil Urease Activity
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7.1.3. Effect of Inorganic Sulfur Compounds

Hoeft (1986) described field experiments carried out on two Illinois soils in 1984 and 1985 for studying the effect of ammonium thiosulfate (ATS) on maize. Urea-ammonium nitrate (UAN) solution was the fertilizer at rates of 134 and 202 kg N/ha. ATS solution was used at a rate supplying 5% of the total N. The two solutions were mixed and surface-applied on soil. The results showed that ATS had no increasing effect on grain yield on any soil and at any fertilizer N rate.

For studying the effect of ATS on no-till maize, Fox et al. (1986) carried out 1-year (1984) field experiments on a silt loam soil in central Pennsylvania. In the ATS solution used, the content of N was 120 g and that of S was 260 g/kg. Fifty ml of the ATS solution and 950 ml of a UAN solution were mixed. Rates of N addition to soil were 67, 134, and 202 kg/ha. UAN alone and UAN-ATS were surface-applied at planting. The grain yields and N uptakes by plants were not significantly different in the UAN-ATS and UAN treatments at any fertilizer rate.

But in 2-year field experiments carried out by Fox and Piekielek (1987) on the silt loam soil in central Pennsylvania, better results were obtained with UAN-ATS than with UAN alone. As the soil was not tilled, approximately 50-80% of the soil surface was covered by plant residues at the time fertilizers were applied (more precisely, after maize was sown but before it emerged). UAN and UAN + ATS were applied as a fine spray. In other treatments in which ATS was not used, UAN was dribbled and ammonium nitrate surface-broadcast. N rates were 50, 100, 150, and 200 kg/ha in all treatments, except in the UAN + ATS treatment, in which N rate was 100 kg/ha. ATS represented 5% of the volume of UAN. In both years, grain yield in the UAN + ATS treatment was higher than that in the UAN treatment and only insignificantly lower than that registered in treatments with dribbled UAN and broadcast NH₄NO₃. Similar results were found in respect of N uptake by maize plants. Therefore, it appeared evident that ATS increased the efficiency of spray-applied UAN. Contrarily to this conclusion, Fox and Piekielek (1993), based on the results of new experiments, conducted over 3 years (1989-1991) on three no-till maize fields on silt loam soils in central Pennsylvania, concluded that amending UAN with ATS had no significant effect on N fertilizer use efficiency of sprayed UAN and only a slight effect on banded UAN.

In the field study of Zadak et al. (1987), UAN with and without ATS was surface band-applied (105 kg/ha) to a clay loam soil cultivated with maize in a ridge-tillage system in Minnesota. To determine the importance of rainfall on N loss, water was applied at various times and rates in the 10-day period following N application. The conclusion was drawn that no significant reductions in urea hydrolysis and no significant increases in maize yields occurred when ATS was used.

Leis et al. (1989) and Varsa et al. (1989) conducted four field experiments in 1987 and 1988 on silt loam soils at two locations (Belleville and Carbondale) in southern Illinois to evaluate the effect of ATS on no-till maize. ATS was added to solution of urea and UAN at rates of 2.5 and 5% of the applied N as ATS-N such that a total application of 134 kg N/ha was made. ATS addition at the 5% rate to urea solution which was then dribble-applied led to a significant (12.4%) grain yield increase only in one of the four experiments. ATS was less effective when broadcast and added to UAN solution.

Eckert et al. (1990), Lamond et al. (1991b), Maddux and Barnes (1991), and McVay et al. (1991) also found, in field experiments carried out in Ohio, Kansas, and Missouri,