Chapter 8. Effect of Urease Inhibitors on Other Enzyme Activities, Microbial Counts and Biomass as well as on Respiration and Other Microbial Processes in Soils

A primordial requirement with which the inhibitors of soil urease activity should comply is the specificity: they should inhibit urease activity effectively without exhibiting negative side effects on the soil life; they should not affect the other enzymatic activities, the microorganisms and microbial processes playing an important role in the biological cycles of elements and in soil fertility.

8.1. EFFECT OF UREASE INHIBITORS ON OTHER ENZYME ACTIVITIES IN SOILS

8.1.1. Effect of Heavy Metal Compounds

In studies on the effects of pesticides on biochemical and microbiological properties of Canadian soils, Tu (1981a,b, 1982, 1990, 1992a,b) used \( \text{HgCl}_2 \) as a reference compound and determined, besides urease activity (see page 10), other enzyme activities as well. Rate of \( \text{HgCl}_2 \) addition was 70 or 80 \( \mu \)g/g soil, and incubation was carried out at 28°C.

Tu (1981a) found that \( \text{HgCl}_2 \) significantly decreased \((p=0.05)\) dehydrogenase and phosphatase activities in a clay loam soil (pH 7.2). In an organic soil (pH 7.2), \( \text{HgCl}_2 \) caused a significant and an insignificant decrease in dehydrogenase activity after 7 and 14 days of incubation, respectively, whereas phosphatase activity was significantly reduced (Tu, 1981b). In another organic soil (pH 6.7-6.8) studied by Tu (1982, 1990), \( \text{HgCl}_2 \) addition led to a significant decrease and to no significant changes in dehydrogenase activity after 7- and 14-day incubation, respectively, but phosphatase activity was not affected significantly. Invertase and amylase activities had significantly increased values in the \( \text{HgCl}_2 \)-treated samples after 2-day incubation, but no significant differences were found between these activities and those measured in the control samples after 3 days of incubation.

In a sandy loam (pH 7.6), Tu (1990, 1992a,b) registered significantly increased dehydrogenase activity due to \( \text{HgCl}_2 \) after each incubation time (2, 7, and 14 days), whereas the effect of \( \text{HgCl}_2 \) on phosphatase activity was insignificantly inhibitory. Invertase and amylase activities were significantly increased and not affected significantly by \( \text{HgCl}_2 \) after 2 and 3 days of incubation, respectively.

Skujins et al. (1986) found that \( \text{CrCl}_3 \) and \( \text{CuCl}_2 \) were stronger inhibitors of nitrogenase than of urease activity in samples of a forest soil (see page 14). Thus, \( \text{Cr}^{3+} \) at 200 \( \mu \)g/g soil rate inactivated the nitrogenase system, but \( \text{Cu}^{2+} \) at its lowest rate (50 \( \mu \)g/g soil) exhibited a stimulatory effect on this enzyme system.

In the pot experiment of Kandeler et al. (1990) (see page 15), the heavy metal salts inhibited not only urease activity but also dehydrogenase, \( \beta \)-glucosidase, cellulase, protease, nitrate reductase, alkaline phosphatase, phospholipase, and arylsulfatase activities, in both soils studied (a sandy loam and a clay loam). Xylanase activity was inhibited in the sandy loam but not in the clay loam. Dehydrogenase, alkaline phosphatase, and arylsulfatase activities were most sensitive to the heavy metal salts.

In the experiment of Benedetti et al. (1990), \( \text{Cr}_2\text{O}_3 \) added to samples of an Italian soil (at a rate of 100 mg Cr/kg soil) caused decreases not only in the urease activity (see
322 page 15) but also in phosphatase and casein-hydrolyzing and Na\textsubscript{\(\alpha\)}-benzoyl-L-argininamide (BAA)-hydrolyzing protease activities.

Chernykh (1991), whose pot experiments are briefly described on page 15, determined the effect of Cd, Pb, and Zn on urease and other, three enzyme activities and drew the conclusion that sensitivity of the activities to these heavy metals when each was applied alone presented the order: urease > invertase > catalase > phosphatase. A partly other order was established when these heavy metals were applied in combination: urease > catalase > invertase > phosphatase. Thus, urease activity was always most sensitive and phosphatase activity least sensitive to Cd, Pb, and Zn.

Soil urease activity in the pot experiment of Kucharski and Niklewska (1992) was inhibited only by the 1,000 ppm Zn rate (see page 16), but dehydrogenase and acid and alkaline phosphatase activities were inhibited also by the 100 and 10 ppm Zn rates, and the extent of inhibition was proportionate to the Zn rate.

Speir et al. (1995) studied the effect of Cr(VI) on soil urease activity (see page 16) and also on phosphatase and arylsulfatase activities and established for these three activities the following order of decreasing sensitivity to Cr(VI): arylsulfatase > phosphatase > urease.

Soil urease activity, as studied by Hemida et al. (1997) (see page 17), was more sensitive than nitrate reductase activity and much more sensitive than amidase activity to Cu\textsuperscript{2+} and Zn\textsuperscript{2+} in both clay and sandy soils studied.

In the pot experiments referred to by Kucharski (1997), Zn inhibited soil urease activity and stimulated dehydrogenase activity, whereas Pb and Cd inhibited both activities (see page 17 and Table 4).

Wyszkowska et al. (2001) found that in their pot experiments the effect of Cr on soil dehydrogenase and acid and alkaline phosphatase activities was similar to the effect exerted by Cr on soil urease activity (see page 19).

In the experiment of Moreno et al. (2001) (see page 19), dehydrogenase activity was also determined. In both soils treated with Cd\textsubscript{SO\textsubscript{4}}, the ED\textsubscript{50} (the Cd concentration inhibiting dehydrogenase activity by 50%) was much higher after 3 hours of incubation than after 28 days. This means that the initial sensitivity of dehydrogenase activity to Cd decreased during the incubation.

\subsection*{8.1.2. Effect of Alkali Metal and Alkaline Earth Metal Salts}

Yarovenko et al. (1982) found that MgCl\textsubscript{2}, NaCl, and MgCl\textsubscript{2}+NaCl increased urease activity in samples of a chernozem containing or not containing residues of vetch-oats (see page 22), whereas the effect of these salts on other soil enzyme activities was highly varied. Thus, in soil samples without crop residues, MgCl\textsubscript{2} did not affect invertase and neutral phosphatase activities, stimulated acid and alkaline phosphatase, nitrate and nitrite reductase activities, and inhibited protease and hydroxylamine reductase activities. NaCl stimulated neutral and alkaline phosphatase activities and inhibited the other activities. MgCl\textsubscript{2}+NaCl did not affect acid phosphatase activity, stimulated neutral and alkaline phosphatase activities, and inhibited the other activities. The inhibitory effect was attenuated or even replaced by stimulatory effect in soil samples containing crop residues.

Garcia and Hernández (1996) treated samples of a calcareous soil with 0.1 to 1.3 M solutions of NaCl and Na\textsubscript{2}SO\textsubscript{4} (see page 26), and found that dehydrogenase and catalase activities were decreased by the 0.1 M NaCl and Na\textsubscript{2}SO\textsubscript{4} solutions and increased by the