Action and Degradation of Dicyandiamide in Soils

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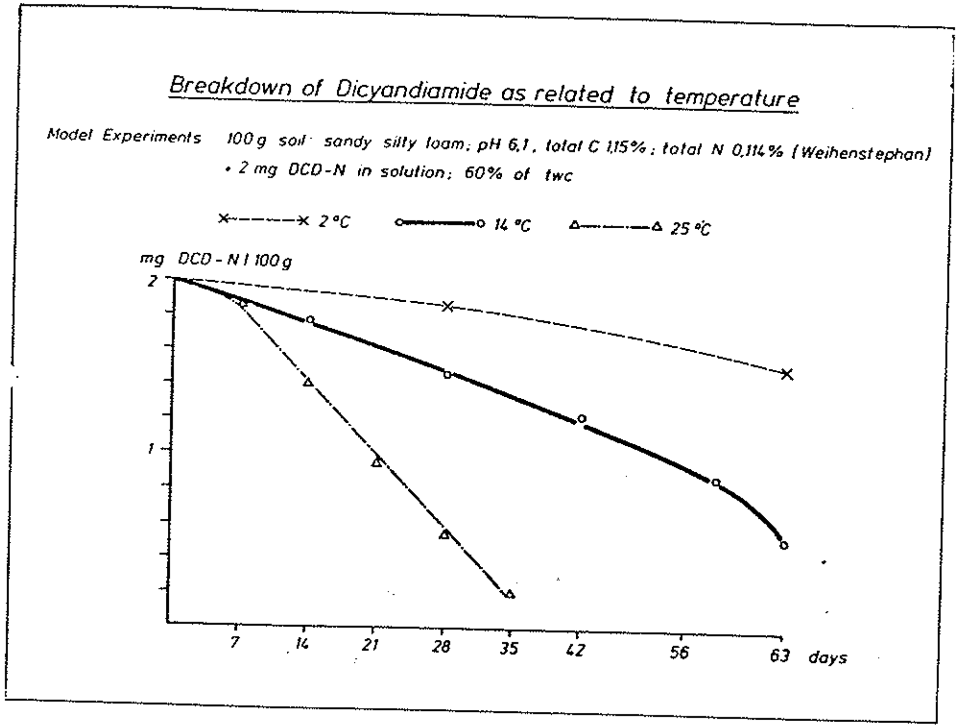
Dicyandiamide (DCD) is a nitrification inhibitor that blocks the transformation of ammonium to nitrite (Amberger and Gutser, 1978; Vilsmeier and Amberger, 1978; Vilsmeier, 1981), thereby allowing better utilization of N. It is essential, however, that only DCD but not its metabolites inhibit nitrification. For this reason, factors that can influence degradation of DCD in soils such as soil moisture and temperature are of primary interest in estimating the length of the nitrification inhibiting period. Investigations have also been done to determine the turnover of DCD in soils and to study the influence of dicyandiamide addition to urea on losses of N under partly anaerobic conditions.

1. Influence of soil moisture and soil temperature on DCD turnover

While soil moisture exerts only little influence on the rate of decomposition of DCD (Amberger and Vilsmeier, 1979), soil temperature determines the turnover of DCD in soil to a large extent, as is shown in figure 1.

Figure 1.



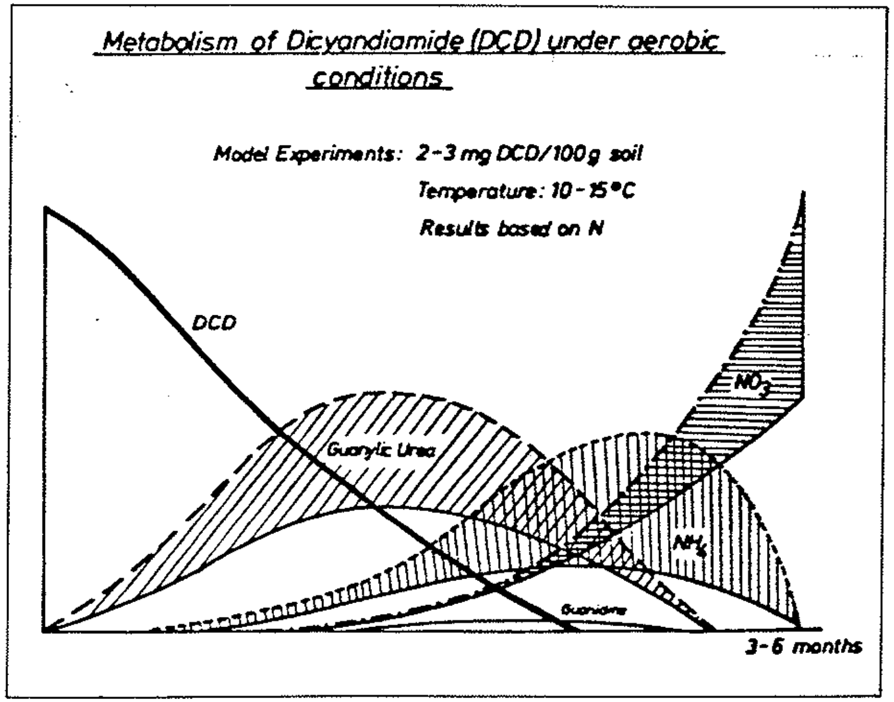
At 14 °C decomposition of DCD is relatively slow in this soil: after 50 days, only about 50 % of the added DCD is broken down. An increase of soil temperature up to 25 °C accelerates the turnover rate of DCD to such a degree that after 35 days no more than 10 % of the original amount of DCD can be detected. Very low temperatures, e.g., 2 °C, markedly slow down the turnover of DCD; after 63 days as little as 20 % of added DCD is decomposed.

Decomposition of DCD in soils and consequently the nitrification inhibiting effect is also determined by some other soil specific parameters, on which we are still working.

2. Decomposition of DCD

According to our present knowledge, based on the results of numerous inverstigations, the transformation of DCD in soils is as follows (Figure 2).

Figure 2.



As a first step, DCD is decomposed to guanylic urea (variations of absolute amounts are shown by marked areas). From guanylic urea, guanidine is formed which, however, can only be detected in traces. Next, guanidine is degraded to ammonium which finally will be nitrified.

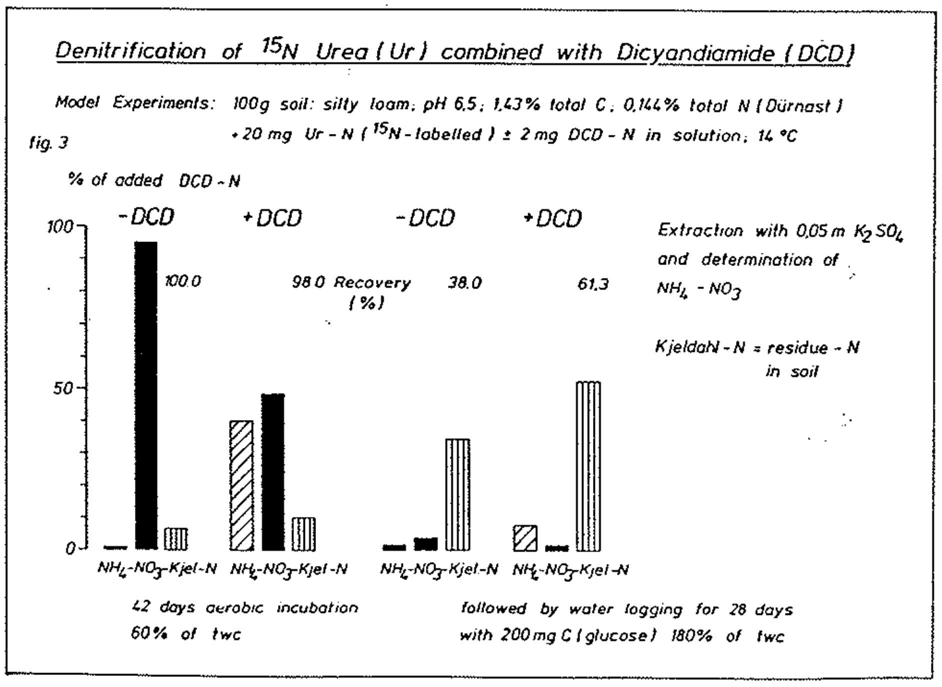
In model trials with ^{15}N-labelled dicyandiamide (publication is under preparation), we could prove that DCD-N is converted via guanylic urea and ammonium almost completely to nitrate, that is, to a fully plant available form of N.

The extent of ammonium versus nitrate formation depends on the nitrification potential of a soil as well as on the extent of immobilization and fixation in the soil, particularly of ammonium.

3. Effects of DCD addition to urea

In an experiment with ^{15}N-urea, we tested the effects of adding DCD under aerobic followed by anaerobic conditions (Figure 3).

Figure 3.



In the beginning, we incubated aerobically for 42 days at 60 % of the total water capacity. Without addition of DCD, urea is converted quickly and almost completely to nitrate. By addition of DCD, nitrification is retarded markedly, although after 42 days 50 % of the original urea-N can be found as nitrate-N. Total recovery of the added N is between 98 and 100 %.

After 42 days of aerobic incubation, soils were waterlogged for 28 days with a solution of glucose at a rate of 200 mg Carbon/100 g soil and at 180 % of the total water holding capacity, and analyzed afterwards. Under waterlogged conditions, recovery values showed that without DCD only 38 % of the original urea-N, but with DCD 61 % could be detected. The largest fraction of the urea-N was found as total soil N (Kjeldahl-N) probably as microbial protein. The ammonium and nitrate fractions contained relatively little labelled N.

According to our experimental set-up, only gaseous losses of N were possible. Addition of glucose with anaerobic conditions probably resulted in strong oxygen consumption which led to denitrification of nitrate. Since in the presence of the nitrification inhibitor, DCD, far smaller amounts of nitrate could be found after 42 days of aerobic incubation, gaseous losses of N in this case were reduced by about 23 % as compared to the control without DCD.

Summary

1. Depending on some parameters, e.g. temperature but also site specific soil factors, DCD is decomposed in soil at varying rates.

2. Dicyandiamide is converted via guanylic urea and ammonium almost completely to nitrate within 3 - 6 months and thus transformed to a plant available form.

3. Addition of dicyandiamide to N fertilizers can result in pronounced reduction of N losses - for instance, by denitrification - because of an initial slower formation of nitrate.

Literature cited

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