

ATRAZINE DEGRADATION IN SOILS - SOIL AND ENVIRONMENTAL FACTORS

Kathleen H. Boumer

CSIRO Division of Irrigation Research, Griffith, New South Wales

D.V. Crawford

University of Nottingham, United Kingdom

Atrazine is widely used as a pre- and post-emergence herbicide in maize, sorghum, and a variety of other crops. Since activity may remain in the soil for up to 18 months after application, there is concern that sensitive crops may be damaged as rotations are intensified. A second aspect is the fate of atrazine and degradation products, which may accumulate in the soil or eventually reach water supplies.

Experiments at the University of Nottingham in 1967-1969 were designed to estimate the effect of soil and environmental factors on the rate and mechanism of atrazine decay with particular reference to the surface few centimetres of soil, which is the relevant region for germinating weed seedlings.

In field experiments atrazine distribution with depth was followed in two different soils using a gas-liquid chromatographic method (GLC). During the same period, temperature and water fluctuations in the surface layers of the soil were recorded. Disappearance of atrazine from the top 6 mm of soil was not paralleled by an increase in deeper layers, suggesting that a breakdown mechanism subject to the fluctuating environment of the surface layers of the soil was operative.

In laboratory studies, atrazine was added to four contrasting soils and incubated at different temperatures and water contents. 'Dry' treatments were obtained by incubating soils in closed containers over saturated salt solutions to control relative humidity. pH was studied using sandy loam soil from a series of plots that had been treated for 6 years with sulphur or lime. Sterile soils (gamma-irradiated or propylene-oxide-treated) were used to estimate the relative importance of biological and non-biological processes.

Observations of atrazine disappearance (GLC) suggested that non-biological processes were usually dominant. When non-sterile soils were incubated with  $^{14}\text{C}$  ring-labelled atrazine the most important degradation product corresponded to hydroxyatrazine on thin layer chromatograms. This is consistent with a non-biological hydrolysis rather than a microbiological dealkylation process.

Atrazine disappearance processes were difficult to quantify because of the complicated nature of the decay. In a clay topsoil and subsoil, decay was apparently exponential; in a silt loam soil and particularly in a sandy loam soil, decay was non-

exponential, showing an initial fast reaction giving way to a subsequent slower reaction. Possible explanations are:

- (1) Atrazine is absorbed at two main types of site - 'active' and 'safe' for degradation - and redistribution equilibrium is slow compared to breakdown rates.
- (2) 'Active' sites may become blocked by breakdown products.

Either of these mechanisms could give rise to the situation of a 'fast' reaction giving way to a slower one.

The reactions appear to have different activation energies, the slower reaction being more temperature-dependent, so the pattern of decomposition may alter with temperature. The effect of temperature on atrazine disappearance in the sandy loam soil was pronounced, the herbicide disappearing very slowly at temperatures below about 20°C; in these circumstances a proportion of the initial application seems to persist for long periods, which may have important agronomic consequences.

Another soil parameter dependent on climate and which can affect the rate of atrazine degradation is water content, but this appears to be less influential than temperature. Within the range measured in the top 6 mm of soil in the field during March-September - i.e. pF 2-6 - the water content had relatively little effect on the laboratory rates of degradation of atrazine in a sandy loam and a silt loam soil. Diffusion and redistribution by water movement may be much more significant factors in the field.