SCIENCE DU SOL n° 1986/1 - pp. 59-60 - PLAISIR-FRANCE

DEGRADATION OF PESTICIDES IN THE SOIL MICROBIAL AND QUANTITATIVE ASPECTS

G. SOULAS [1]

(Science du Sol 1985/2)

In that article we try to distinguish between some of the biological processes by which microorganisms acquire new catalytic functions that allow them to transform xenobiotic substances. Degradation probably occurs by recruiting preexisting enzymes capable of acting on different substrates particularly if they are analogues of natural compounds (fig. 1). Two main obstacles to efficient degradation are that new chemicals are not always able to induce synthesis of the enzymes involved in their own degradation and that they are often poor substrates for these enzymes. These difficulties may be overcome by different processes — i : gene duplication that increases the basal level of enzyme production — ii : regulatory mutations that give "constitutive mutants" capable of producing large amounts of enzymes — iii : mutations in the structural genes that give altered enzymes with an increased affinity for the new substrate (fig. 2). It seems now probable that considerable contribution to the genetic adaptation of microorganisms to their environment could be made by exchange of genetic information carried on transmissible extrachromosomal elements (plasmids) between members of a microbial community. Such genetic transfert may result in the coexistence of microorganisms with different biochemical capacities (fig. 3) that may be divided into two main categories : the metabolizing microbes able to grow at the expense of the pesticide and the cometabilizing ones that, as isolated species, cannot use the pesticide as C and energy source but may express their respective and complementary degradative capacities within a microbial community (fig. 4, 5).

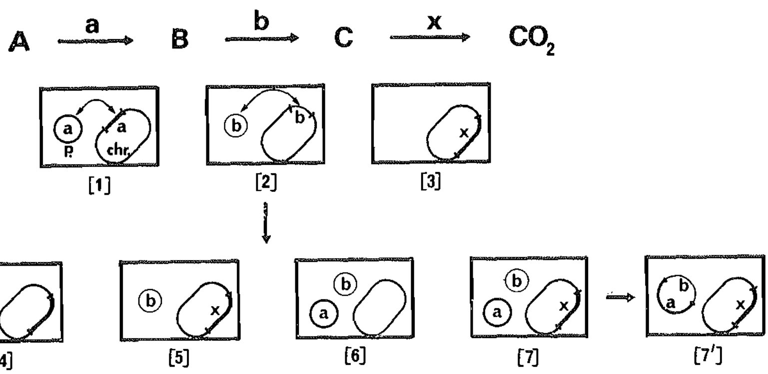

Figure 3 : Adaptation by exchange of genetic material

Strain (1) has acquired the ability to transform A into B. Responsible genes (a) are coded either on the chromosome (chr) or on a transmissible plasmid (p). Strain (2) is able to transform B into C. Corresponding genes are located on a plasmid supposed to be transmissible. Strain (3) uses compound C as carbon and energy source due to the genes x.

Exchange of plasmids between theses strains gives individuals with different biochemical capacities : (4) transforms A, accumulates B and uses C as carbon and energy source ; (6) transforms A and B and accumulates C ; (7) and (7') use A as carbon and energy source.

(1) INRA - Laboratoire de Miocrobiologie des Sols, 17, rue Sully, 21034 Dijon Cedex.

Then we try to relate above mentionned biochemical peculiarities and their distribution in the soil biomass to observed kinetics of pesticide degradation (fig. 6).

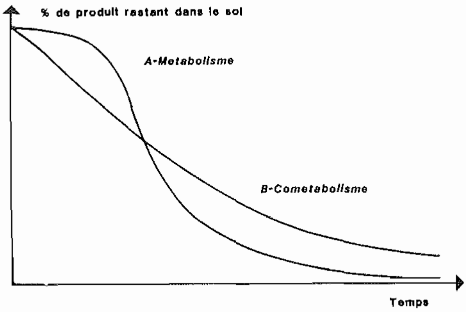

Figure 6 : Main types of breakdown kinetics of pesticides in the soil.

Some of the main theoretical models of pesticide degradation in the soil are introduced. We first examine models the formulation of which is based on equations of chemical kinetics. Some examples are given (Table 1). Their use as predictive models is discussed in the light of the example developped many years ago by WALKER (fig. 7, 8). Biological models that take into account dynamics of microbial populations are also presented. A brief description is given of a theoretical model we recently developped (fig. 9). Comparison between simulated and observed results are given (fig. 10) to illustrate the possible use of such model as methodological tool for scientific investigation.

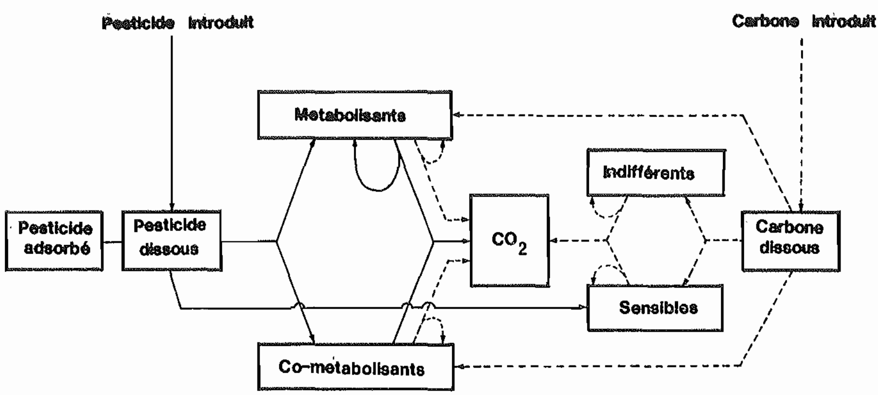

Figure 9 : Degradation of pesticides in the soil. The main microbial groups. (Solid arrows are related to pesticide and metabolites flow. Dashed arrows are related to the flow of other carbon substrates.)