DIFFERENT TRANSFERS PATTERNS

with different types of soil cultivation


The absence of soil cultivation will modify the properties of the soil surface.

Soil cultivation has a complex effect on pesticide transfer: it involves multiple processes with differing effects. Recent research has shown that the increased microbial activity of a non-inverted soil does not necessarily reduce the risk of pesticide transfer.

BY modifying soil properties, cultivation has an impact on what happens to pesticides. Those changes are physical and hydrological, as well as physico-chemical (Organic matter, pH) and biological (microbial community, fauna). The effect of soil cultivation on pesticide transfer depends heavily on solclime conditions (soil type, rainfall, etc.). Cropping techniques and crop rotation also play a considerable role.

The role of mulches

The intensity and dynamics of pesticide transfers are closely linked to the way the porosity of a soil profile is structured. The strength of the desorption (release) and pesticide degradation processes is also determined by the level of moisture in the soil.

With a non-inversion tillage system (NITs), two factors determine what happens to pesticides: changes in soil condition and presence of mulch. Mulch comes from crop residue left on the ground when the soil ceases to be inverted. It intercepts pesticides, and therefore determines the proportion of pesticides that directly reaches the soil after its application. It also helps to delay pesticides leaching through the soil. This interception encourages phenomena such as photodegradation and volatilisation. The persistence of pesticides on and in mulch is controlled by retention processes (adsorption/desorption), transformation processes (microbial degradation), and transport processes (leaching, volatilisation). Their mechanisms are specific to mulch.

Find out more

« Faut-il travailler le sol ? » (“Soil cultivation or not ?”), éditions ARVALIS-Institut du végétal - QUAE,
150 p., *in French*, available at www.editions-arvalis.fr

Plough in a field. Herbicide flows are proving lower when fields are ploughed than with a non-inversion system.

pH and pesticides

Assessing what happens to pesticides in a no-tillage system requires in-depth knowledge of the interaction between pesticide retention and mulch decomposition. As it decomposes, the physical and physico-chemical properties of this organic matter are modified, including through differential biodegradation of some biochemical constituents, colonisation of microorganisms instrumental in the decomposition process (bacteria, fungi), and the fragmentation process due to mesofauna and macrofauna in the soil. For example, glyphosate retained on the surface of mulch will leach more readily as the mulch decomposes further.

The main difference resulting from the absence of tillage compared with conventional techniques is the redistribution of organic carbon in the soil. With a non-inversion tillage system, the organic carbon content of the first few centimetres of soil is higher, due to a build-up of organic matter linked to the presence and decomposition of mulch. It then reduces gradually through deeper layers. Most pesticides are more readily adsorbed into the soil surface with a NITs system than when the ground is ploughed.

Non-inversion techniques generally contribute to acidifying the surface horizons. Yet, the retention of many active ingredients tends to increase as the pH is lowered.

The decomposition of mulch also affects other microbial activities involved in the degradation of pesticides. A soil study carried out in Argentina in 2011 (Rampoldi et al.) compared what happens to glyphosate on bare soil and on the same soil when it is covered with mulch. After 7 weeks, 74% of glyphosate has been mineralised on bare soil, as opposed to only 27% on mulch.

The half-life period in the soil of glyphosate associated with plant residue can be up to six times longer than for glyphosate applied directly to the ground (insert).

Porosity of soil surface

With a non-inversion tillage system, the concentration of plant residue on the surface encourages the development of fungi contributing to the incomplete degradation of pesticides.

A trial carried out in the silty capped soils of the Sundgau region (Alsace, northeastern France) since 2002 has been measuring the impact of soil cultivation on run-off and herbicide transfers in maize monoculture. This study has shown that there is much less run-off with NITs than when the field is ploughed.

For example, in the non-inverted parcel, 27 mm of rain generated 5% of the volume of run-off recorded in the ploughed parcel. Run-off soon stopped, whereas it continued for over 5 hours in the ploughed field.

Over a whole maize cropping season, not only was the volume of run-off lower with NITs but the first run-off also occurred later.

Lower volumes of run-off when NITs are being implemented reduce the risk of herbicide transfer. In addition, since the first run-off occurrence is delayed by several months, herbicides applied in April and May have started degrading by then: the quantities available for transfer by run-off are much lower.

The presence of crop residue increases the roughness of the ground surface, slows run-off speed, and reduces the erodability of the soil. This in turn reduces herbicide transfers.

Moreover, infiltrometry measurements have confirmed that the porosity of the soil surface is improved, which also helps to limit the volume of run-off.

Nitrate trapping cover crops to limit transfers

In maize monoculture with irrigation, minimum soil cultivation combined with the establishment of an interseasonal crop (such as a Nitrate trapping cover crop) limits the loss of isoxaflutole and diacetonitrile (herbicides used as an alternative to atrazine). With nitrate trapping cover crops, herbicide loss was 1.6 times lower than in ploughed fields. By combining nitrate trapping cover crops and cover crops during intercropping season, it was 4.5 times lower.

Finally, the number of different earthworm species found does show that there is no great difference in population numbers between the two systems.

Transfert times

It is often suggested that the absence of cultivation increases the risk of vertical transfer. However, this should be treated with caution. Although the absence of tillage might encourage poral continuity and result in greater quantities of water infiltrating the soil, studies have shown that this is not systematically the case in the field. The monitoring of various transfer times showed equal numbers of cases in favour of ploughing as of non-inversion.

However, the hydrodynamic behaviour of untilled fields is always the same at the beginning of the drainage season (when drains first start running): With NITs, the first flow peaks are always more intense, whereas the flow stops more quickly during and at the end of the season. With a non-inversion system, this behaviour can result in greater transfers of autumn herbicides, applied before the start of the drainage season, and in a reduced risk of transfer of herbicides applied to spring crops.

Active ingredients that have relatively long (several months) half-lives and that are applied in spring give rise to lesser transfers in non-inverted fields. There is greater biological activity in subsurface soil and this may lead to faster degradation than in ploughed fields.

What happens to pesticide in the soil is a question arising with many herbicides, especially glyphosate, wich is heavily used in non-inversion systems.

Mulch and volatilisation

Since soil cultivation affects the properties of the soil surface, it also has a significant impact on the process of volatilisation from the soil. Volatilisation usually increases as the temperature rises. But if the soil has dried out, the adsorption process from the gaseous phase results in reduced volatilisation. Moreover, incorporation into the ground significantly reduces the volatilisation of the most volatile compounds.

Mulches also have a significant impact on volatilisation, because they form an extensive area of contact with the atmosphere and are able to intercept a large proportion of the quantities of product applied. Other factors come into play and modify the temperature and moisture of the soil surface. In spite of the lack of data to assess the effect of mulch on volatilisation, mulch seems to have an impact on the dynamics of volatilisation by modifying conditions at the soil surface. Therefore, any process that influences the availability of pesticides in mulch is going to have repercussions on the intensity of the volatilisation process.

The absence of soil cultivation alone does not reduce pesticide transfers. In addition, the absence of tillage often sees an increased use of non-selective herbicides, such as glyphosate, during the intercropping season. As current knowledge stands, arable crop systems must combine soil cultivation technique management and practices aiming to reduce the use of chemicals to control agrestal weeds. In addition to improving water quality, this objective also helps to prevent the development of resistance to herbicides, which is bound to happen. All those factors point in favour of the rapid development of alternative technical solutions.

Pierre Benoit - benoit@grignon.inra.fr
INRA
Benoît Réal - b.real@arvalisinstitutduvegetal.fr
ARVALIS - Institut du végétal

March 2015

« By modifying ground surface conditions, mulch seems to have an impact on the dynamics of volatilisation »

Transfer risks vary depending on the soil type, the rainfall and soil cultivation choices made as part of the overall cropping system.