Hydromorphic soils

What is the effect of drainage on crop yields and the transfer of solutes?

The drainage of cultivated hydromorphic soils stabilises and increases the yields of winter crops and improves tillage conditions. By allowing the infiltration of water into the soil, it favours the transfer of soluble elements, particularly nitrogen. On the other hand, it limits peak flow rates, reduces runoff and with it the loss of soil particles and elements fixed on these particles such as phosphorus and certain active ingredients from pesticides.

Since the 1990s, an experiment has been installed at the ARVALIS – Institut du végétal station at La Jaillière in the Loire-Atlantique, with the objective of measuring the effects of cultural practices on the quality of surface waters. Eleven plots, each of 0.5-1 ha, are equipped to collect the drainage and runoff water separately, to measure the flows and regularly collect water samples. In a period of flow, an average sample is made up each week on each of the plots and is then sent to the laboratory for analysis.

The transfers of nitrogen, phosphorus and certain pesticides into surface waters are thus measured.

The results presented in this article are those from two plots with a forage maize / wheat succession, one being drained and the other not. The analysis of surface runoff water has only been carried out since 1994, the date when effective runoff traps were installed.

Over the period 1994-2009, the mean volume of water collected was 290 mm on the drained plot, including 260 mm as drainage and 30 mm as runoff, as against 215 mm runoff on the undrained plot. The extremes go from 25 mm in 2005, a dry winter, to 600 mm in 2001, a very wet winter (figure 1).

The runoff observed on the drained and undrained plot is mainly winter runoff. It happens when the soil is saturated with water and the perched ground water rises to the soil surface.
Effect of drainage on crop yields

Drainage stabilises the yields of winter wheat. On the drained plot, the yield is usually between 7 and 8.5 t/ha as against 4 to 7 t/ha on the undrained plot. The mean yield over 17 seasons is increased by 1.4 t/ha.

The mean yield of forage maize differs little between the drained and undrained plots. These crop yield results must be viewed in context as they were obtained on experimental plots of about 1 ha.

The undrained plot probably benefits from the drainage of the drained plots which surround it by not receiving the runoff water from these plots. Moreover the number of days available for tillage is smaller in the undrained plot than in the drained plot, but because of the small area to be tilled, the experimenter usually manages to do the work in acceptable conditions, which would not be the case on a farm scale where the areas to be tilled are larger.

Effect of drainage on the transfer of nitrogen

Drainage encourages the infiltration of water into the soil. As it returns to the drains, this water takes up nitrogen which is usually distributed over the whole of the profile. Because of this, the concentrations and fluxes of nitrogen in the drainage water are always higher than those in the runoff water from the undrained plot (figure 2). The losses of nitrogen in the drainage water can be controlled by the adoption of good practices: well-controlled nitrogen fertilisation, cover crops between cash crops, control of yield (e.g. by irrigation in the case of maize).

Effect of drainage on peak flow rates, water turbidity and suspended matter load

Drainage, by allowing the infiltration of water into the soil, reduces the peak flow rates after a rain event. For example, following a fall of rain of 7.5 mm, 5 mm is lost by runoff in 17 hours on an undrained plot whereas it takes 43 hours by drainage on a drained plot. In this case, the peak flow rate is 14 m³ per hectare per hour by runoff on the undrained plot, as against 4 m³ per hectare per hour by drainage on the drained plot. In the drained plot, the soil thus has a buffering effect by storing and then returning the water through the drainage network.

The measurements of turbidity and suspended matter show that the passage of soil particles is greater in the runoff water from the undrained plot than in the drainage water from the drained plot.

Intake of the drainage collectors and runoff in the overflow trays for measuring the flow rates and collecting water samples.
Effect of drainage on transfers of phosphorus and plant pharmaceutical molecules

With the same phosphate fertilisation practices in the drained and undrained situation, the phosphorus fluxes in the runoff water from the undrained plot were 80% higher than the total of the drainage and runoff fluxes from the drained plot. A large proportion (40% in runoff and 60% in drainage) of the pesticides applied was not (or hardly) found in the water leaving the cultivated plots. They were more often detected in the runoff water from the undrained plot than in the drainage waters from the drained plot, and often at higher concentrations. Apart from atrazine (banned since 2003) and isoproturon, the quantities transferred were always higher in the runoff water of the undrained plot than in the drainage water and runoff water combined from the drained plot (figure 3). As for glyphosate, over the three seasons of study, two had applications at the end of winter (mid-February for one and the beginning of March for the other) at times of drainage, and the third at the end of summer (the beginning of August), i.e. four months before the beginning of drainage. In the case of the application at the end of summer, the amount transferred was very small and represented only 10% of that measured after the applications made at the end of winter.

By encouraging infiltration of water into the soil, drainage reduces peak flows.

In certain situations drainage helps to reduce runoff and the transport of soil particles and elements attached to these particles, such as phosphorus and pesticides.