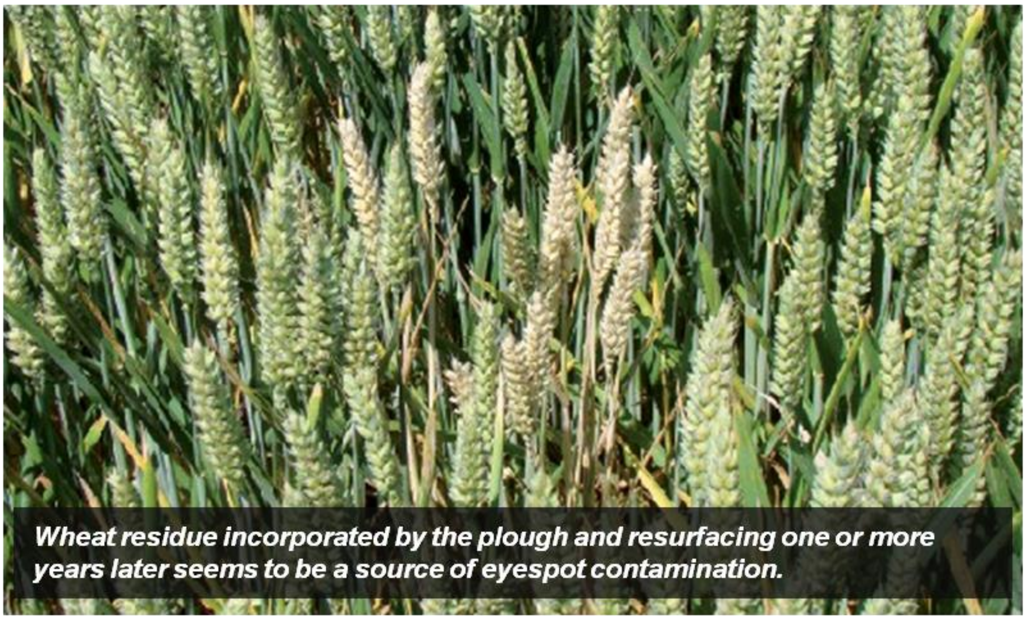
THERE IS A LINK BETWEEN SOIL CULTIVATION, previous crops and disease development



Wheat residue incorporated by the plough and resurfacing one or more years later seems to be a source of eyespot contamination.

The soil cultivation trial being carried out at Boigneville, near Paris, is highlighting complex interactions between soil cultivation, crop rotation and the biology of individual fungi.

Several observations made as part of the long term trial being carried out at Boigneville (near Paris) have confirmed the impact of soil cultivation and crop rotation on wheat diseases.

Soft wheat was compared after three different crops: wheat (wheat monoculture), grain maize (maize-wheat rotation) and sugar beet (sugar beet-wheat-pulses-spring barley) (1). The wheat crop management was fairly similar for all types of soil cultivation and preceding crops: same variety and identical fungicide programme most of the time. Some different measures were taken in maize (after wheat) and spring barley (after peas or fababean). In all cases, three different soil cultivation methods were implemented: ploughing, superficial cultivation and direct drilling.

Soil cultivation does not restrict the efficacy of fungicides

A comparison with and without fungicide was carried out between 1974 and 2009 for wheat monoculture. On average, fungicides provided an additional 1.2 t/ha, with important variations from one year to another (from 0 to over 4.5 t/ha). The soil cultivation method used had little effect on the yield increases provided by fungicides for a given year or on average over several years. The pressure from parasitic fungi on the cereal plants was however sometimes very different depending on whether the soil was tilled or not. The impact varies depending on the disease. For example, wheat leaf blight (Helminthosporium) is more prevalent with direct drilling, whereas eyespot is more common when the soil is ploughed. This variation is due to the epidemiology of each individual fungus.

Ploughing and monoculture encourage the development of eyespot

The previous crop has a significant impact on the development of eyespot in wheat. The effect was greater in monoculture than after grain maize or sugar beet. Regardless of the previous crop, ploughing encouraged the development of eyespot much more than superficial cultivation and direct drilling, which can seem surprising. Wheat residue incorporated by the plough and resurfacing one or several year(s) later certainly seems to be a greater source of infection than if it is left on the surface where it is subjected to a more intense antagonistic microflora. On this point, INRA obtained contradicting results in wheat after wheat, with less eyespot when the soil had been ploughed. In that case, the straw from the first wheat is incorporated by the plough and does not affect the second wheat crop. That context is different from wheat monoculture (third wheat or more) where ploughing inevitably brings back up old wheat straw.

Direct impact on septoria

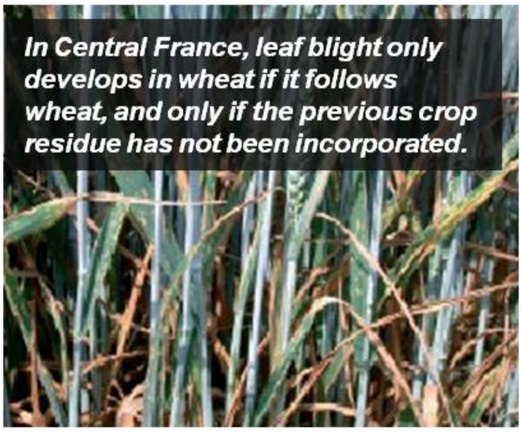
The observations made in wheat grown after maize or wheat, quite logically revealed that the type of soil cultivation chosen had no noticeable impact on rusts, yellow or brown, or powdery mildew (table 1). In the autumn, the inoculum always originates from outside the field, and has therefore no connection with the type of soil cultivation selected.

> « **The impact varies,** with, for example, more prevalent leaf blight after direct drilling, whereas eyespot is more common when the soil is ploughed. »

However, in our trials, ploughing encouraged the development of septoria in autumn and winter, in particular in wheat grown after maize. Such observations may be explained by the lower biomass of direct drilled wheat after maize: It is more difficult to establish because of the high quantity of residue left by irrigated grain maize. And septoria spreads from leaf to leaf through the “splash effect”. It is therefore encouraged by denser vegetation.

The case is very different for wheat leaf blight in wheat, which is encouraged by the unincorporated straw from the previous wheat crop. This leaf disease is non-existent in the Boigneville area, except in wheat grown after wheat (especially in monoculture). It was noted in 2003 and 2006, when Caphorn, a variety that is very sensitive to leaf blight, was grown as part of the trial. After it was replaced by a tan spot resistant variety, this disease occurred very little in wheat, making way for septoria. Observations made over five seasons (1974, 1975, 2003, 2005 and 2006) showed that crop rotation, ploughing and fungicide treatments significantly reduced leaf blight infestations. The first two of those levers proved the most effective ones.

> « Between 1974 and 2009, fungicides provided an average increase of 1.2 t/ha. »



In Central France, leaf blight only develops in wheat if it follows wheat, and only if the previous crop residue has not been incorporated.

Contaminating residue left on the ground also encourages the development of fusarium.

Observations have shown similarities between fusarium and an associated mycotoxin (deoxynivalenol, also known as DON), and wheat leaf blight. Soil cultivation has no significant impact on crops that follow species that do not encourage the disease (e.g. wheat and sugar beet). However, after a crop prone to the disease and the residue of which carries significant levels of inoculum (e.g. grain maize), soil cultivation has a real impact. Cropping practices that leave a large amount of residue on the ground encourage ascospores to contaminate the ear. They, in turn, can encourage the development of fusarium if the variety in question is sensitive to it and conditions are damp.

High DON levels (greater than the regulatory limit of 1,250 µg/kg in untreated soft wheat grain) are often found after grain maize. This can occur when the soil is ploughed, but is even more common with direct drilling. After other crops, the 1,250 µg/kg limit was virtually never exceeded. The average DON content is, unsurprisingly, higher after sugar beet than after winter soft wheat, because sugar beet residue also carries fusarium inoculum.

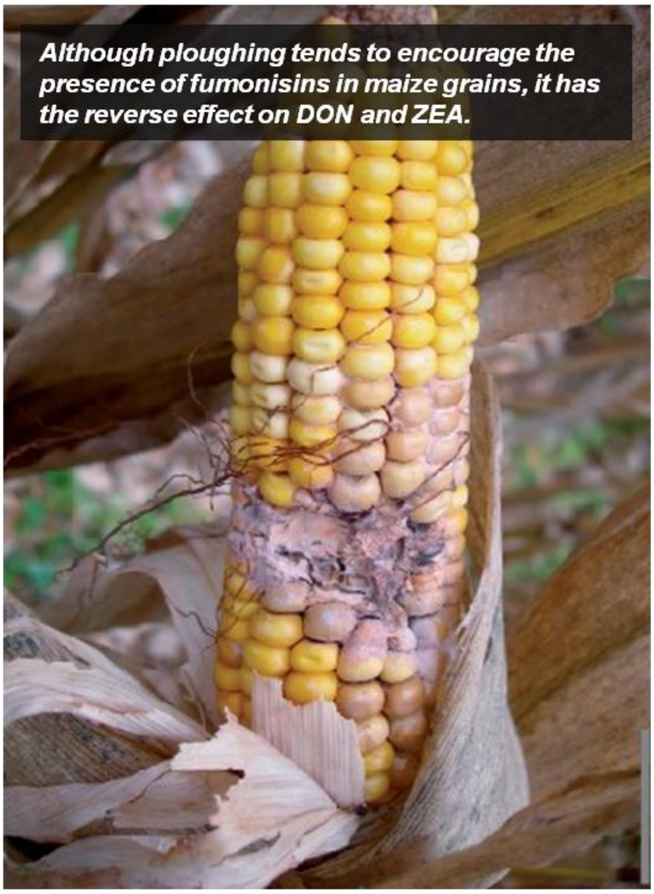
Cropping practices that leave a large amount of residue on the ground encourage fusarium ascospores to contaminate the ear.

Maize: soil cultivation has a widely varying effect on mycotoxins

The average mycotoxin content [deoxynivalenol (DON), zearalenone (ZEA), nivalenol (NIV) and fumonisins B1 and B2 (FUMO)] of maize grains has been recorded regularly since 2003. On average, the absence of ploughing increased the risk of high DON and ZEA (table 2) contents. But soil cultivation had an extremely variable effect on the mycotoxin content from one year to another. This is probably due to a combination of risk factors: quantity of contaminating residue left on the ground, flowering date, rainfall or irrigation at flowering time, etc.

Cover crops established between wheat and maize (primarily oats in this trial) tended to increase the DON, ZEA or NIV content of maize grain, especially in 2010 and in the absence of ploughing. This impact seems magnified if the cover is destroyed late, as this leaves more residue on the ground when maize is being planted. This residue can act as a carrier for fusarium inoculum. Those results are still to be confirmed and developed with trials focusing on the ability of various cover species to carry fusarium type fungi.

> « **Cover crops established between wheat and maize** tended to increase the level of DON, ZEA or NIV in maize grains. »



Ploughing encourages the development of fumonisins

Fumonisin levels were only significant in 2006. Then, soil cultivation had a very marked impact, with much greater levels when the soil had been ploughed than when it had been superficially cultivated or direct drilled. There was no indication of the effect that any cover crop might have.

Those results are in line with those of many trials and investigations, showing that the fumonisin levels found in maize established without ploughing are lower than in maize established after ploughing, albeit with very significant variations from one place and one year to another. The opposite trend is true for DON and ZEA.

After maize or wheat, the incidence of maize common smut (Ustilago maydis) grew lower with the reduction in soil cultivation (table 2).

Mycotoxin levels recorded in spring barley between 2007 and 2011 were non-existent or very low for DON and T2 and HT2 toxins, regardless of the establishment method used.

(1) See Perspectives Agricoles N° 400 page 31 and following pages

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Find out more

You can find this article on www.perspectives-agricoles.com, with mycotoxin levels found in wheat grains depending on the soil cultivation and harvest residues management.

WHEAT DISEASES : the efficiency of agronomic lever

	Wheat - Monoculture			Wheat after maize			Wheat after sugar beet		
	tillage	shallow tillage	direct drilling	tillage	shallow tillage	Direct drilling	tillage	shallow tillage	direct drilling
Rusts	+	+	+	+	+	+	+	+	+
Oidium	+	+	+	+	+	+	+	+	+
Septoria	+++++	+++	+++	+++	+	+	+++	+	?
Eyespot	+++++	+++	+++	+++	+	+	+++	+	?
Fusarium head blight/DON	+	+	+	+++	++++	+++++	++	++	++
Fusarium stem	?	?	?	+	++	++	?	?	?
Wheat leaf blight	+++	++++	+++++	0	0	0	0	0	0

Table 1 : Impact of soil tillage and crop rotations on winter wheat diseases (soil cultivation trial in Boigneville).
+++++ : high impact of agronomical factors ;
+++ : moderate impact of agronomical factors ;
+ : low impact of agronomical factors (other factors : climate, genetics…) ;
0 : no occurrence of disease ;
? : no data available.

MAIZE DISEASES : DON et ZEA mycotoxins are greatly influenced by agronomy

	Maize afer wheat		
	tillage	shallow tillage	direct drilling
Fusarium stem	+	+	+
Common smut (Ustilago)	+++	++	+
DON	+++	++++	+++++
ZEA	+++	++++	+++++
FUMO	+++++	++++	+++
NIV	+	+	+

Table 2 : Impact of soil tillage and crop rotations on maize diseases and mycotoxins (soil cultivation trial in Boigneville).
+++++ : high impact of agronomical factors ;
+++ : moderate impact of agronomical factors ;
+ : low impact of agronomical factors (other factors : climate, genetics…).