Fusarium blight – a global problem

The diseases caused when various cereal varieties are infected by *Fusarium* species of fungal pathogens are among the most important and potentially damaging in the world, particularly in the wheat-growing regions of the USA, Canada, Argentina, Australia and Europe.

Since the beginning of the 1990s, there has been a marked increase in the incidence of diseases caused by *Fusarium*. The risk of infection has increased through changes in crop production: for example, with the increase in minimal cultivation; through an increase in the frequency of cereal crops in the rotation; and as the result of an extension of the area under maize cultivation.

Fusarium infections can occur at the stem base, on leaves, and on the ears. By far the greatest damage is caused by the pathogens *Fusarium graminearum* and *F. culmorum* when they infect the ears. Because these pathogens produce mycotoxins, they may directly limit the use of infected grain in food and feed production.

Mycotoxins are dangerous to people and animals

Head blight leads to lower thousand grain weights and numbers of grains per ear, and also reduces the vitality of the seed. Yield losses of up to 50% can result. The disease also reduces baking quality in wheat and can adversely affect the brewing process when infected barley is used.

Even more important though is the ability of *Fusarium* pathogens to produce mycotoxins – i.e. fungal metabolic products – that are toxic to people and animals, causing serious damage to the organism even at low concentrations.

The most important fusaritoxins produced on cereals in the field are nivalenol (NIV), deoxynivalenol (DON) – particularly in wheat and triticale – and zearalenon (ZEA). Durum wheat is particularly vulnerable, barley and rye less so.

Typical symptom: bleached ears

Infection and re-infection by *F. graminearum* and *F. culmorum* lead to the bleaching of individual ears, or of groups of ears. A brown-violet colouration is often seen on the rachis. Where the weather is favourable, orange-red to pink spore-bodies develop on the base of the spikelet and the edges of glumes. The symptoms can differ slightly in appearance, depending on the type of cereal infected – wheat, triticale, oats, rye, summer- or winter-barley.

Infection by conidia and ascospores

The pathogens overwinter in the field mainly as conidia and ascospores on moribund plant remains, such as straw and stubble. Conidiospores can infect ears after being spread – in rain-splash droplets – from leaf to leaf up the stem: but wind-borne ascospores are also important for direct infection of ears, particularly for *F. graminearum*. The ascospores develop in fruiting bodies called perithecia that form on infected organic remains lying on the soil surface. The perithecia eventually ripen, extruding the ascospores.

If spore-release is followed by sustained, cool and damp weather, a symptom-less multiplication of spores can take place. As ascospores are only dispersed over short distances, infections in a particular field are usually initiated by inoculum from within that field.

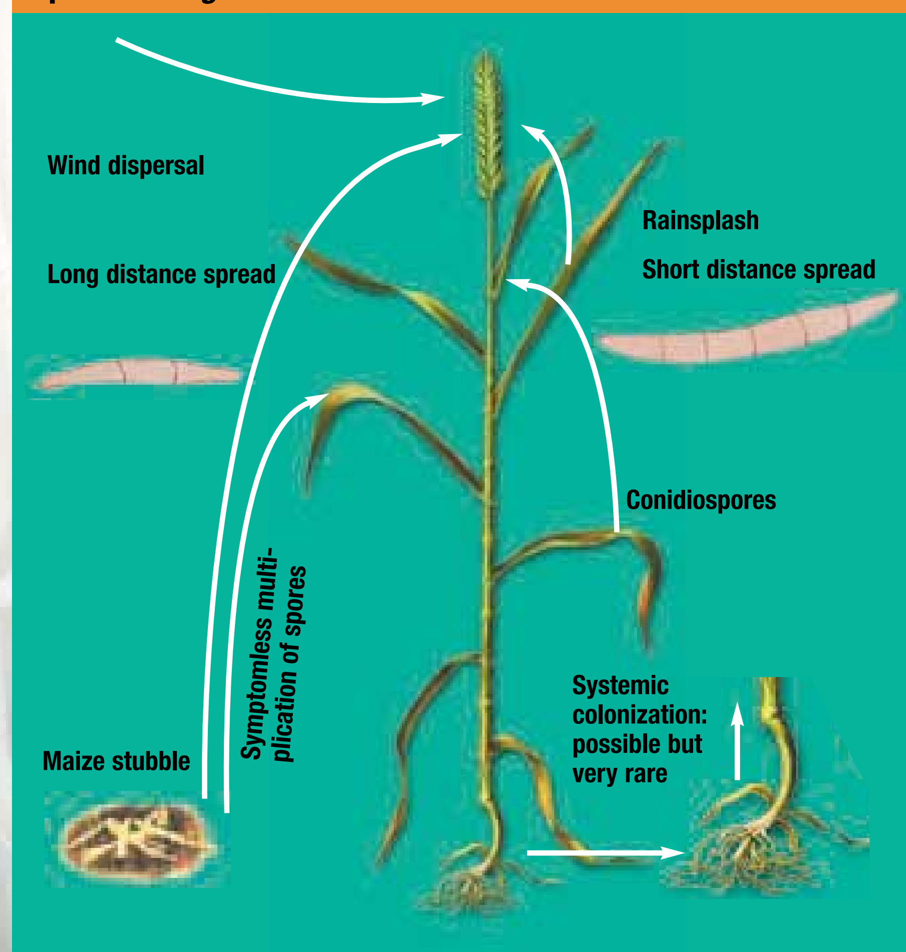
Successful infection depends on the crop being at the susceptible flowering stage at the time of spore release, when the pathogen can penetrate the plant tissues with infection hyphae as soon as the spores germinate. The anthers, the ovary, and stomata on the inner surfaces of the glumes are the most important routes of infection. Following successful infection, the pathogen grows inwards towards the stem. If infection is severe, the pathogen produces large amounts of mycelium in the vascular bundles of the stem, thereby inhibiting the transport of nutrients to developing seeds at higher positions on the ear. The result is partial or complete whitening of ears, or whiteheads.

Weather and inoculum potential determine the severity of infection

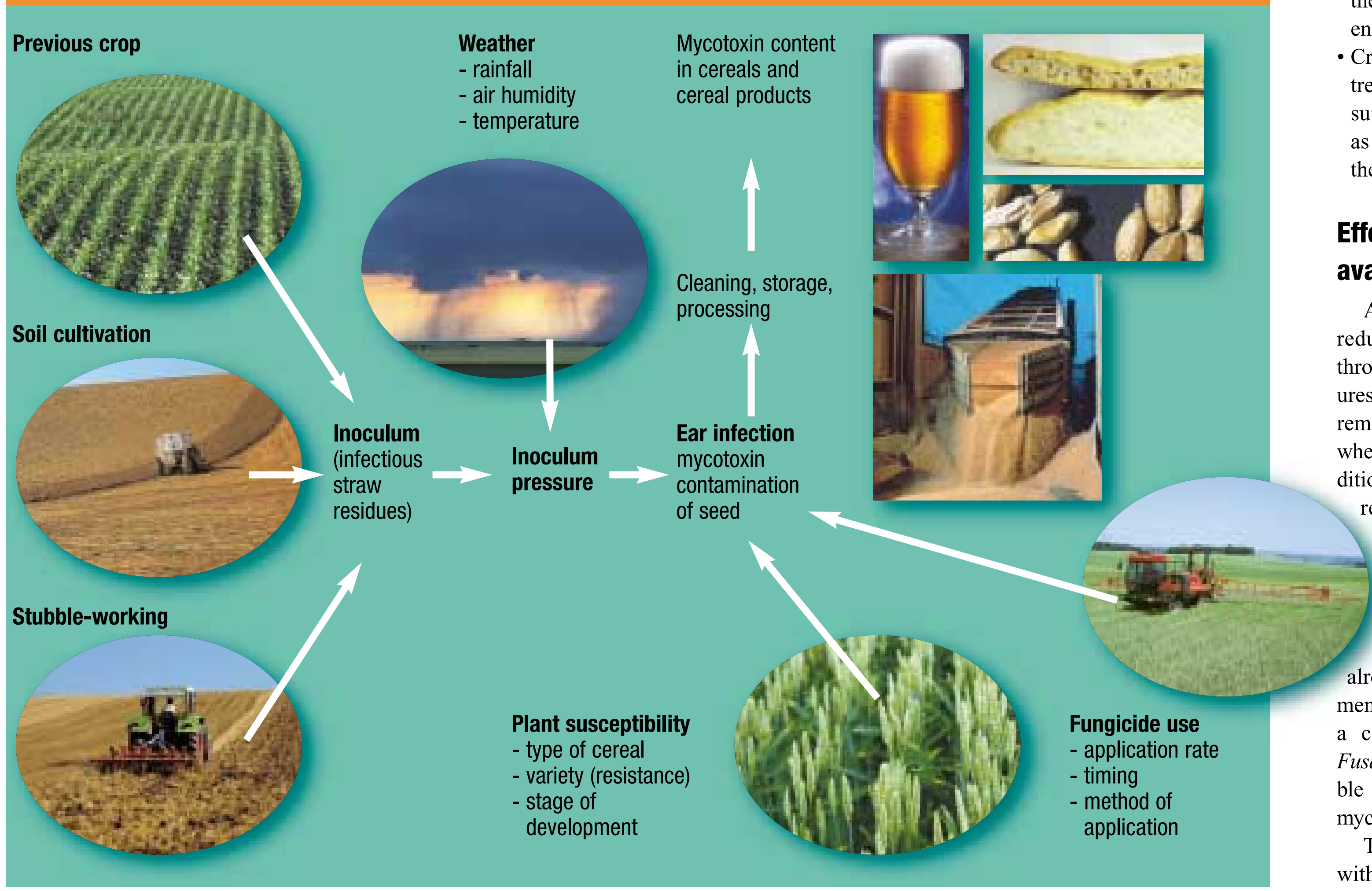
Previous crop, soil cultivation, choice of variety, weather conditions and the use of fungicides are the most important factors influencing the incidence of *Fusarium* infections. Of these factors, previous crop and soil cultivation directly influence the size of the inoculum potential. The combination of initial inoculum potential and weather conditions determines, in turn, the build-up of inoculum that can eventually lead to head blight infections. The severity of these infections is then determined by the susceptibility of crop plants (stage of development/varietal resistance) and the use of fungicides.

Changeable, damp weather at the time of the beginning of ear emergence is particularly favorable for infection. The damaging *Fusarium* pathogens require, at temperatures greater than 20 °C, a wetness period of at least 24-40 hours in order to be able to infect. While wheat is flowering, rainfall

Spread of *F. graminearum*



Factors influencing infection by *Fusarium* pathogens



of as little as 3-5 mm and a minimum temperature of 16-18 °C can mean a very high risk of infection. The various *Fusarium* species differ most strongly in terms of their temperature requirements for infection: (*F. culmorum:* 16-18 °C; *F. graminearum:* 20-22 °C). Warm, damp weather between the flowering and ripening of cereal crops, combined with delayed harvest, encourage the spread of the pathogens and the contamination of the corn with toxins.

Main source of inoculum: maize stubble

Short rotations that are based mainly on cereals – and particularly maize – present *Fusarium* pathogens with a succession of susceptible crops. Stubble and other residues remaining on the soil surface, particularly slowly-rotting maize straw, present a source of inoculum throughout the entire vegetation period, thereby increasing the risk of infection of succeeding crops. Minimal cultivation therefore encourages infection considerably: depending on the technology and methods used, a large proportion of the crop residue remains on the surface, or in the uppermost soil layers. In a study in France, harvested seed from direct-seeded wheat grown after maize had a fourfold higher DON-content than that from wheat grown after ploughing; with minimal cultivation, the content was twice as high as with ploughing.

Clearly, then, working stubble into the soil by ploughing reduces the risk of infection considerably. However, once-incorporated stubble that is brought up to the surface again during ploughing in preparation for a subsequent crop remains a source of inoculum if the stubble has not rotted fully, which can happen where there are anaerobic conditions, especially on heavy soils. The highest risk of all occurs when direct-drilled wheat follows maize. The second most risky succession – albeit with a significantly lower infection risk, is direct-drilled wheat after wheat.

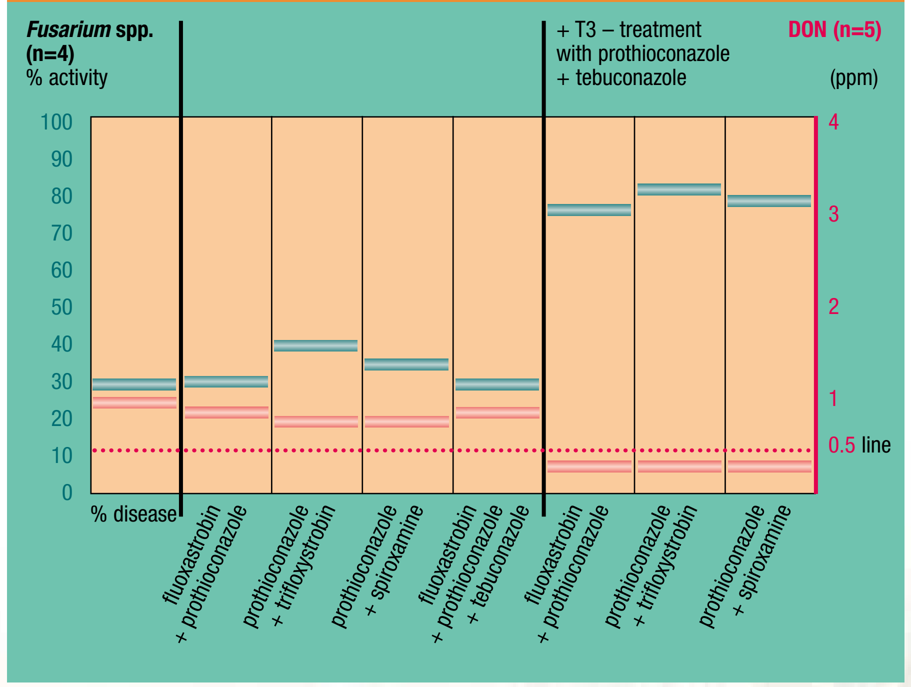
Various strategies are necessary for reducing infection

The farmer needs to take certain agronomic measures to avoid *Fusarium* infection, not least because the harvest must not contain toxins at concentrations above the strict contamination limits.

Depending on location and other factors, the following measures can be taken to reduce the incidence of infection:

- Careful choice of crops in the rotation: reduction in the number of maize or cereal crops in an extended rotation
- Choice of variety: cultivating those that are resistant to *Fusarium*
- Working-in stubble and cultivating soil: turning over the soil reduces the risk of infection; with conservation tillage, additional chopping-up and even distribution of crop residues accelerates microbial degradation in the topsoil (which may be encouraged by adding urea); avoiding the formation of mats of organic matter
- Appropriate crop nutrition: avoiding weak crop growth or lodging – both can increase susceptibility to infection – by fertilizing according to the crop's requirements.
- Harvesting as soon as the crop reaches the appropriate stage of ripening (low enough moisture content)
- Crop protection/use of fungicides: Seed-treatment, sprays to leaves and ears with suitable products (active substances such as tebuconazole, prothioconazole) reduce the infection pressure

Effect of T2 treatments on mycotoxin production
(Winter wheat 2004)



Effective fungicides are available

Although much can be achieved to reduce the risk of *Fusarium* infection through the preparatory agronomic measures discussed above, weather conditions remain an important factor in determining whether infection takes hold or not. If conditions occur that favour infection, little remains for the farmer but to use *Fusarium*-controlling fungicides to limit the severity of infection – and most importantly, to reduce mycotoxin production.

If latent *Fusarium*-infection is already present at the time of leaf treatment, it makes sense to use a product with a component that is effective against *Fusarium*. Doing so can lead to a measurable reduction in *Fusarium* infection and mycotoxin contamination.

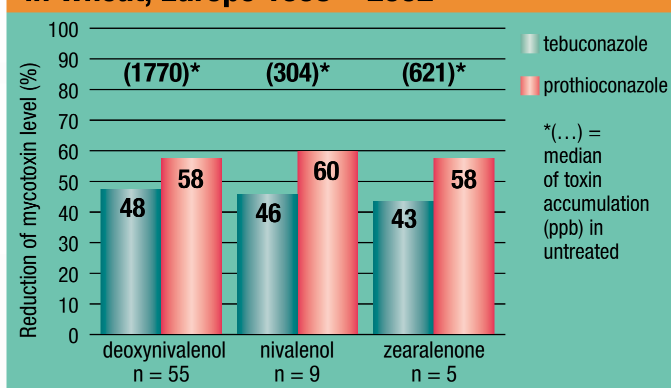
Trials in which cereal ears were treated with azole fungicides (active substances such as tebuconazole or prothioconazole) clearly showed that if the timing of treatment is right, head blight infection – and consequently toxin contamination – can be considerably reduced. In field trials in several years in France, Germany and the United Kingdom, Folicur® (tebuconazole) markedly reduced infection by *Fusarium* pathogens in more than half of the wheat varieties tested, and reduced the content of DON in the seed by an average of 50%.

Multi-site field trials in several years have also been done with the new fungicidal active substance prothioconazole (key tradename: Proline®) in order to investigate its effectiveness against infection, the resulting yield benefit, and its effect on the level of mycotoxin contamination of the seed. In all of the parameters investigated, treatment with prothioconazole produced even more impressive results, compared with the untreated control: a reduction in the incidence of infection of up to 90 %; in the severity of infection of up to 92%; and a 70% increase in yield. The level of toxin contamination was also reduced by 60%.

The right timing for treatment

The strong dependency of *Fusarium* species on the right weather conditions for infection means that the application window for optimal treatment with fungicides is very narrow. The best time to spray during flowering is one to two days after the pathogen has infected during the first favourable period of rain after the beginning of ear emergence (ca. 30-40% of ears emerged). Sprays can be much less effective if they are applied only a few days too early or too late. Tests with prothioconazole across several years showed that on average, the optimal timing for use of this active substance lay from three days before flowering to three days after flowering. However, *Fusarium* infection will only be reduced successfully if, during the remainder of vegetative growth, the crop achieves the dry stage of ripening, thereby restricting the ability of *Fusarium* to develop further. ■

Effect of prothioconazole on mycotoxin levels in wheat, Europe 1998 – 2002



Fungicide application timing