The losses caused by septoria understood

Septoria is the most damaging leaf disease of wheat diseases. Experiments were carried out in order to develop a reliable indicator capable of determining associated yield losses: the healthy area duration. This work paves the way for developing reliable decision-making tools and improving varietal characterisation in relation to septoria.

Helped by rainsplash, septoria can creep up and gradually spread to the different leaf layersas the stem extends.

Wheat leaf diseases, in particular septoria, are those that affect yield the most. Potential reduction in pesticide use requires modified control strategies through the use of effective decision-making tools. Up until now, the decision to apply a treatment has been based on a threshold system of observation of the level of attack at a given date. The correlation between those thresholds and actual losses due to the disease (yield or quality) is often limited: the relation between symptoms and yield can be very good in a given trial, but becomes much less reliable when looking at it for several trials.

Leaf diseases disrupt growth via several mechanisms (or damage functions): reduced green area on leaf due to the space taken by lesions, disease-induced senescence, disruption of the photosynthesis of remaining green areas, increased respiration and removal of dry matter by the fungus.

The work carried out jointly on the ARVALIS - Institut du végétal trial network in the northern half of France, as well as on the INRA Grignon site (near Paris has helped to understand more precisely the mechanisms involved in losses caused by diseases, taking account of criteria such as variety, fertilisation and density.

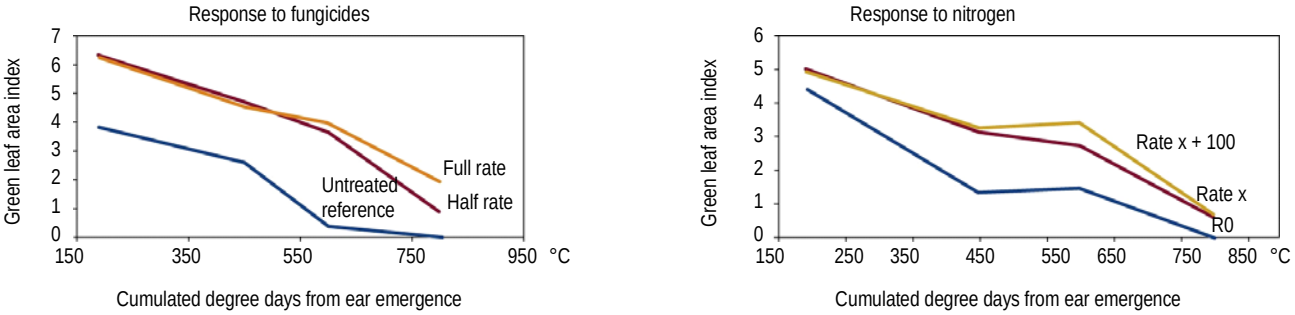
Biology of septoria and wheat plants

The fungus responsible for septoria exists in two forms: sexual *(Mycosphaerella graminicola)* and asexual *(Septoria tritici)*. During a growing cycle, the sexual form is responsible for the first infections in the autumn, through ascospores carried by the wind. Those ascospores germinate on the surface of the first leaves, and penetrate them through the stomata. Mycelium develops, causing leaf tissue necrosis, forming black structures, visible to the naked eye, called pycnidia. The asexual form then drives the epidemic. When hit by raindrops, pycnidia release pycnidiospores, which are carried to healthy leaves (youngest ones) by rain. They germinate and repeat the process.

The time gap between leaf contamination and appearance of pycnidia is much longer than the gap between the production of 2 successive leaves by a wheat plant. Septoria therefore “falls behind” compared to leaf emergence, and this delay is greater if weather conditions are not favourable for it.

Different fungicide and nitrogen rates were applied, and yield measurements were combined with repeated measurements of the green leaf area index, septoria symptoms and senescence *(figure 1)*.

Changes in the green leaf area index after flowering, as influenced by fungicides and nitrogen (experimental site of Estrées-Mons in northern France, 2004) *(fig. 1)*



Time is expressed degree-days from ear emergence. The fungicide dose response trial is on the left; nitrogen dose trial is on the right, rate x being the recommended rate. This shows that the effects of septoria and nitrogen deficiency have a similar impact on the green leaf area index.

Some varieties, like Cabestan and Cockpit, can develop very high green leaf area indices, partly because of the size of their leaves: even if the disease hits them hard, they are left with enough green area to fill the grain.

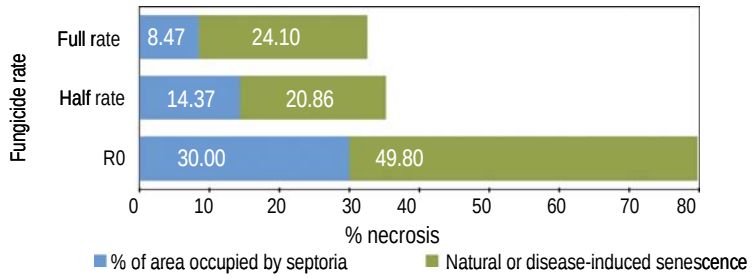
Effects of septoria

The measurements carried out helped to quantify each of the damage functions. Among other things, those measurements showed that the reduction in leaf photosynthesis is proportional to the area occupied by septoria lesions and senescence. They also showed that this senescence increases greatly during septoria attacks *(figure 2)*.

With septoria, growth penalties are mainly due to the area occupied by the lesions and the senescence caused by the fungus.

Using a plant growth model which accurately simulates plant growth under attack by disease, showed that only two damage functions had to be taken into account to determine yield losses due to septoria: loss of green area due to septoria lesions, and increase in senescence.

Relative impact of the area occupied by the leaf disease and natural or disease-induced senescence on the overall loss of green leaf area index. (fig. 2)



Average of measurements taken early dough stage for 3 different fungicide rates (full rate, half rate and untreated reference, R0)

Green leaf area index decreases during septoria attacks.

Estimating the healthy area duration helps to reliably determine yield losses.

Relation between yield and healthy area duration during the filling phase, for different types of environments, of varieties and of nitrogen and fungicide management *(fig. 3)*

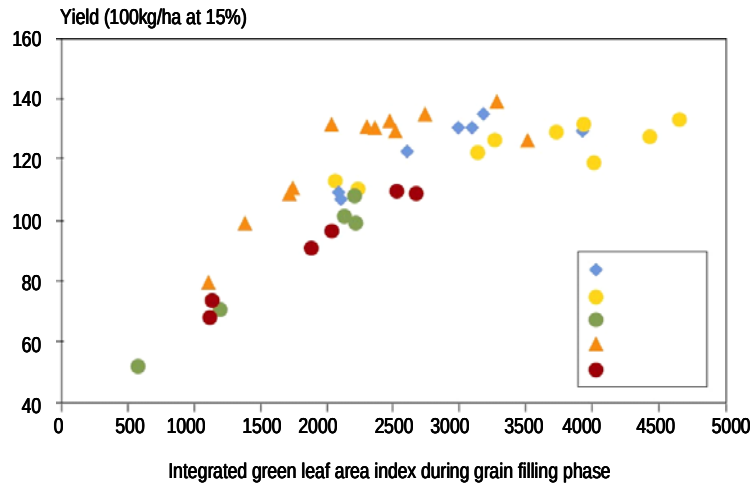


Figure 3 shows that the correlation between healthy area duration and yield is very reliable, regardless of the environment, but that it is dependant on the variety.

Figure 3 highlights the significant differences in tolerance to stress between varieties: placed under equal amounts of stress, tolerant varieties produce 2 tonnes/ha more than those which are less tolerant.

The measurements needed to determine the healthy area duration remain quite time-consuming, but the use of radiometric measurements seems to be a promising solution, which will be tested in the coming years.

In order to assess the reduction in the green leaf area index over time, an indicator which could be measured in the field had to be chosen. The concept of healthy area duration was preferred. This index corresponds to the green area occupied by the leaves per unit of soil area, throughout the filling phase. Healthy area duration quantifies and gives information on yield losses due to the reduction in the green leaf area index during the grain-filling phase *(figure 3)*.

Practical use of the healthy area duration

Healthy area duration helps to quantify, using the same scale, all the different stresses resulting in a reduction in green area: leaf diseases (septoria, rusts), nitrogen deficiency, drought. This makes it a very powerful agronomical diagnosis tool to characterize and compare fields suffering from a combination of different sources of stress. For example, the reaction of different varieties to those stresses can be compared.

Senescence: a natural, and useful process

The senescence process is an active physiological phenomenon which occurs even in healthy plants with a good nitrogen supply. It helps the plant recycle nitrogen: proteins present in the senescent organs are degraded into amino acids carried to developing organs. From the filling stage, nitrogen is remobilized towards the grain, with a significant impact on the protein content. In cases of nitrogen deficiency, the critical nitrogen content which triggers the onset of the senescence process is reached sooner, resulting in an early drop in the green leaf area index, which, once quantified, helps to give a reliable evaluation of yield penalties. The fact that the senescence process speeds up during a septoria attack suggests that this disease disrupts the nitrogen metabolism of the leaves.

Healthy area duration and decision-making

Healthy area duration calculations help to predict the yield of a field as soon as it is possible to obtain both its leaf area index and information on disease development in it, regardless of the the environment. Decision support systems which would forecast losses due to disease combiinge a disease development model with a measurement of leaf area index by remote sensing are thus foreseeable.

Finally, this formal approach helps to account for several foliar diseases, like the brown rust-septoria complex. This progress is also of prime importance for decision-making, as plant protection decisions are made according to the risk posed by multiple disease.

The estimated green leaf area index is the total leaf area (m^2 of leaf per m^2 of soil) minus the area occupied by lesions and senescence.

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Wheat leaf diseases are those that reduce yields the most.