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Take-all
Predicting the risk of damage

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ROTHAMSTED RESEARCH

Key Points

Take-all survives between crops as mycelium in or on host residues – these are the most important source of inoculum.

Research has identified that inoculum, measured through a wheat seedling bioassay, can indicate the potential risk to a following crop.

Cultivars can differ in their ability to build up inoculum in the soil but further research is needed to determine how this can be exploited in disease management.

Soil inoculum levels were high after the 2007 cereal harvest, consequently the potential take-all risk for the 2008 crop is high.

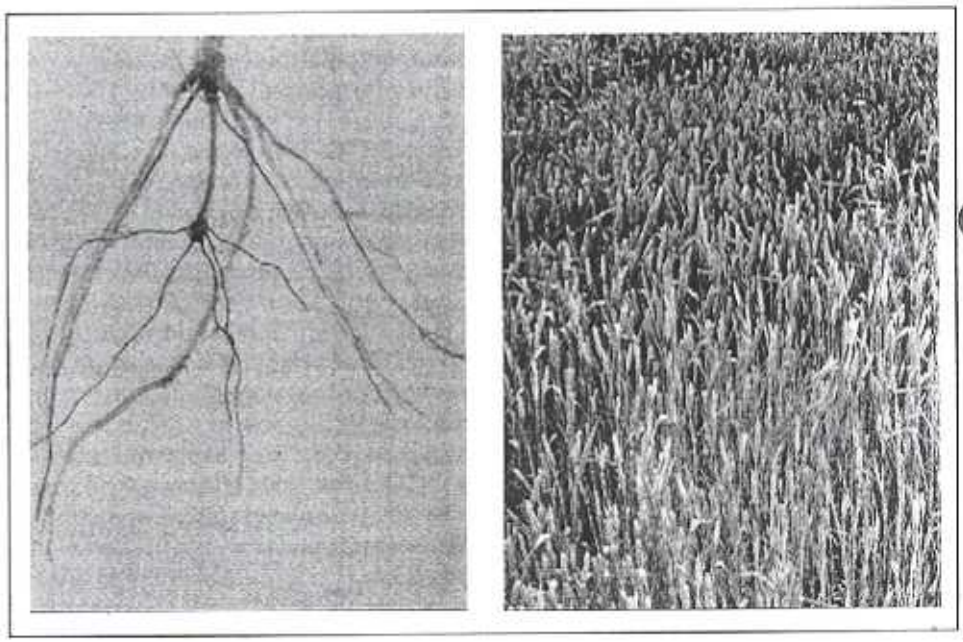

Figure 1 Take-all symptoms on wheat roots, showing as black necrotic lesions, and aboveground symptoms of the disease, showing as stunted, prematurely ripening plants in patches.

Take all is known worldwide and is commonly regarded as the most damaging root disease of wheat. In the U.K. alone losses of up to £55M p.a. have been ascribed to the disease. Take-all is caused by the fungus *Gaeumannomyces graminis* var. *tritici* and when infection occurs, the fungus spreads along the root by means of runner hyphae. These hyphae then send infection pegs through the outer root cells and into the vascular system where they eventually cause a blockage. At this stage typical disease symptoms can be seen as black necrotic lesions on the roots. If the disease becomes severe then typical aboveground symptoms can be seen as stunted, prematurely ripening plants (Figure 1).

The disease is usually only a problem when two or more susceptible cereal crops are grown consecutively. The fungus survives in the absence of a living host as mycelium in or on host root residues and these are the most important sources of inoculum for the following crops. The infectivity of the colonised root residues decreases over time due to decomposition and in general smaller root fragments decompose faster than larger fragments (smaller root fragments also usually require warmer soils to infect new hosts). The rate of decay of soil-borne inoculum is probably influenced by many factors but inoculum concentrations usually decrease to levels that are difficult to detect in germinating seedlings in under a year; this explains why a one-year break is normally sufficient to provide effective control of the disease.

First wheats grown after 'clean' break-crops (i.e. where carriers of the take-all fungus such as cereal volunteers and other host grasses have been controlled) will usually have fewer than 15% plants infected and often these plants will only show slight symptoms. However, a following second wheat crop could be severely affected as a result of this level of inoculum build up under the crop.

Research at Rothamsted has shown that infective inoculum starts to build up in first wheat crops in the top 10-15cm layer of soil in April/May, in favourable conditions, and continues to increase through to harvest. The amount of inoculum in the soil after the harvest of the first wheat crop can also be shown to be clearly related to the severity of take all in the following second wheat crop. However this relationship is not consistent between years; this is probably because it is dependent on a range of variables such as weather, soil nutrients (especially phosphate), cultivation practices and the sowing date of the subsequent crop.

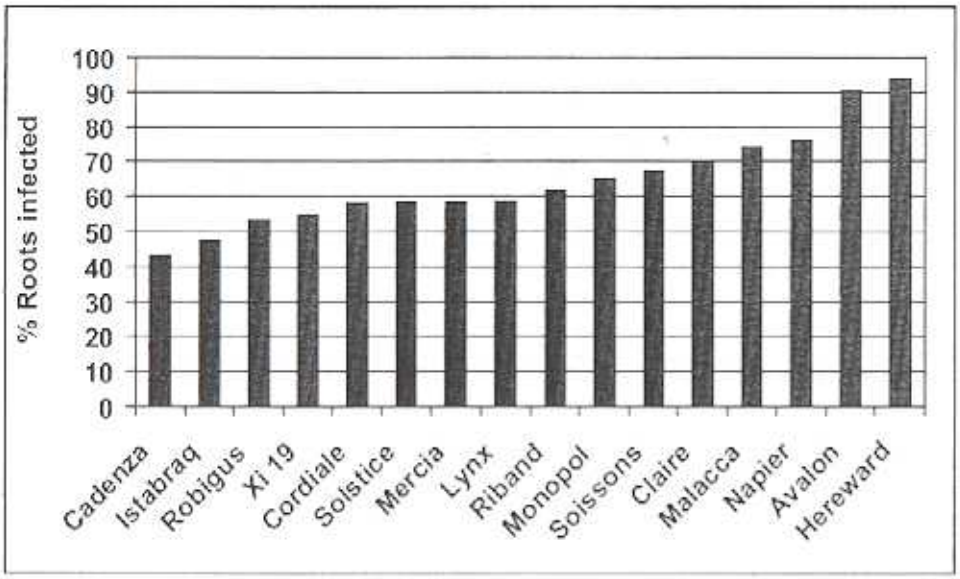

Figure 2 Assessment of take-all infectivity of the soil following the production of a range of winter wheat varieties. Take-all infectivity (inoculum) measured via a wheat seedling bioassay after harvest 2007. Percent roots infected relates to the infection caused in a seedling bioassay following production of the named wheat variety.

Winter wheat cultivars and build-up of take-all inoculum

In the 1980s, results from experimental work carried out at Saxmundham indicated that take-all inoculum built up more under the cultivar Avalon than under the cultivar Norman, when grown as first wheat crops. This work lead to more detailed experimental work where take-all inoculum was assessed in winter wheat cultivar trials at Rothamsted. The results showed that there were some reasonably consistent differences between cultivars in the build-up of inoculum however these differences were smaller than those seen at Saxmundham.

The Wheat Genetic Improvement Network (WGIN) project funded by Defra, which started in 2003 (for further information see www.wgin.org.uk), has two overall aims. Firstly, to generate pre-breeding material carrying novel traits for the use by breeding companies, and secondly, to deliver accessible technologies thereby ensuring the means are available to produce new, improved cultivars. Within this project a series of experiments, started in the autumn of 2003, were designed to study the nitrogen use efficiency of different European commercial winter wheat cultivars.

These large experiments also provided an opportunity to further test the hypothesis that cultivars can differ in their ability to build up the take-all fungus at the start of an epidemic. In the first three years not all cultivars were studied for take-all, instead a selection was made based on available genetic marker information. Soil cores were taken from selected variety plots using an auger soon after harvest and these were then sown with untreated Hereward seed. Pots were kept in a growth room and watered regularly and after five weeks roots were washed and examined for take-all lesions. Total numbers of plants and roots infected were recorded.

Results from the first three years showed that the cultivars sampled could apparently build up take-all infectivity (i.e. inoculum) in the soil differentially during the growth of the first crop. The Hereward plots consistently gave the most root infection in the bioassay, Cadenza gave the least and Riband was intermediate. In 2007, all cultivars were sampled and results indicated that cultivars do indeed differ in their ability to build up take-all inoculum in the soil (Figure 2). The differences were broadly consistent with previous years data and the cultivar Avalon again demonstrated a tendency to build up high levels of the take-all fungus, agreeing with results obtained from the early Saxmundham study.

Take-all risk for 2008

The build-up of take-all inoculum in 2007 was exceptional and reflected the very favourable weather conditions i.e. moist, warm soils throughout May to harvest. However, the conditions that prevailed in the two previous seasons will also have contributed. In 2005, inoculum build-up was reasonably good and in 2006, soils were very dry and although not conducive to inoculum build-up, were favourable for inoculum survival. A first wheat in 2007 grown after a break-crop in 2006 would, therefore, have had slightly more take-all infection than normal, although not severe enough to show the above-ground symptoms of the disease. However it is fair to assume that disease (and potential infectivity) started at a higher level than usual and was consequently able to increase more rapidly under the very favourable conditions. The late harvest in 2007, due to uneven ripening and poor conditions for harvesting, also gave an extended period for inoculum build-up. Collectively, this means that second wheats grown in the 2007-08 season are more likely to be seriously affected if weather conditions are favourable for the disease.

The 2007-08 season started with mild moist conditions in autumn/early winter, conducive to the disease, but the cold February/March has halted progress. Samples taken in early March 2008 where inoculum level was moderate indicated around two thirds of plants to be infected with an average of two infected roots per plant; this scenario has the potential for severe disease should conditions favour development (moist warm spring, followed by hot dry summer).

The Future

Further work will continue to investigate the inoculum build up on a range of wheat cultivars and soil types. The information gained will be used to guide further research that will test cultivars under different disease pressures and help formulate recommendations of how best to exploit the cultivar/inoculum build up phenomenon in disease management.