EXTRACT FROM THE GERMAN MAGAZINE „INNOVATION“

BARLEY YELLOW DWARF VIRUS

BON THE DAMAGE IT CAN CAUSE, THE INFLUENCE OF CLIMATE CHANGE ON THE SPREAD OF THE VIRUS AND THE ADVANTAGES OF RESISTANT VARIETIES

Symptoms of the virus and the economic damage it can cause

Barley yellow dwarf is one of the most widespread and damaging viral diseases in cereals and wild grasses. The virus infects the vascular bundles and spreads along them in the plant. It is persistently transmitted by various aphid species, e.g. the oat aphid (*Rhopalosiphum padi*) and the large cereal aphid (*Sitobion avenae*), whereby the oat aphid is the main vector of the barley yellow dwarf virus (BYDV) in barley and wheat. Visible symptoms of BYDV infection in barley include stunted growth and a yellow or red discolouration of the leaves, which can often form infested patches in the field (Figure 1 and 2). As the main consequence of a BYDV infection, the sieve elements in the vascular bundles collapse, which causes necrosis. This, in turn, results in the breakdown of nutrient transport within the plants at an early stage of development – to the effect that the growing tissue is no longer supplied with sufficient nutrients. This is reflected in a reduced root dry weight and readuced leaf area. If infected plants produce ears, the number and size of grains per ear will be reduced.

The overall losses caused by the virus are estimated to account for about 1% of the total wheat yields worldwide and for about 3.3% in north-western Europe. Based on such estimates, it is obvious that growing BYDV-resistant varieties can reduce or prevent such losses. Virus resistant varieties re-

Fig. 1: Discolouration of the leaves is typical of barley yellow dwarf virus infestation.

Fig. 2: Nest-like infestations are a typical sign of barley yellow dwarf virus.

duce the proliferation and spread of the virus in the plant. Although a virus tolerant variety has no impact on the multiplication of the pathogen, it does produce lower losses in terms of yield and quality than virus varieties susceptible to the virus.

The influence of climate change

Scientists expect damage to cereal crops caused by BYDV to increase in the future as a result of climate change. Climate change causes rising temperatures and increased CO_2 levels, both of which are intertwined. It also leads to changes precipitation levels and distribution. It seems likely that the main barley (1. Europe, 2. Asia) and wheat growing regions (1. Asia, 2. Europe) will be affected by a rise in mean temperature of about 1–2 °C by 2100 (RCP2.6 Scenario; IPCC). The atmospheric CO2 levels are expected to increase to up to 650 ppm – provided that the air temperature does not rise by more than 1.5 °C. When these conditions were simulated in a lab setting, the BYDV virus levels in infected plants increased. Climate change also causes these high virus levels to have a bigger impact on the host plant. These two factors combine and increase the likelihood of virus transmission. Populations of the oat leaf aphid, which reproduce exclusively by parthenogenesis, increase in mild winter conditions, which means that laying eggs on winter hosts becomes less common. Animals that hibernate on the cereal plants help the aphids colonise further fields earlier on in the spring. Warmer conditions still lead to significant flight activity even in late autumn. As the average temperature increases, the aphids develop faster and reproduction begins earlier.

Controlling barley yellow dwarf virus

In this scenario, growing varieties that are resistant or tolerant to BYDV presents an effective solution, espcially as it is not possible to control BYDV with chemicals and as insecticides against aphids that transmit BYDV can be applied only to a limited degree. Plant breeding therefore plays an important role here. The use of molecular techniques in plant breeding facilitates and accelerates the identification of genes that offer resistance to BYDV and their use for breeding. Genotypic and phenotypic characteristics of a large number of plant genotypes, consisting of susceptibles and resistors, allow the identification of molecular markers for a resistance gene. These markers are an important tool for determining the presence of resistance genes during the breeding process. Today, efficient methods of high-throughput genotyping and a reference barley genome sequence are available, enabling rapid marker development. For resistance screening, it is necessary that systematic infections of genotypes with virus-transmitting aphids and the collection of phenotypic data (e.g. virus content, growth height, yield) are carried out with great accuracy. This is the only way to achieve a reliable selection of BYDV-resistant/tolerant plants. Thanks to a close cooperation between research institutites and breeding companies it is possible to swiftly transfer new methods to the breeding process. Wild material from different origins is also included in the screening in addition to (old) varieties. For example, the Ryd2 gene, which is resistant to barley yellow dwarf virus, comes from native Ethiopian barley breeds. The effect of the Ryd2 gene depends on the genetic background of the plant, the environmental conditions and the virus isolate. The Ryd2 gene reduces virus levels in young plants. In older plants, however, no differences were observed between these and susceptible plants. However, this does not affect the economic importance of Ryd2, because an infection of young plants has the biggest impact on yields, whereas there is little or no impact when older plants are infected.

The effect of Ryd2 resistance on aphids

Aphids use volatile organic compounds (VOCs) of the plants to find their host plants. Any changes in VOCs – such that individual compounds increase or the ratios of various compounds change – can influence the identification of host plant by aphids. Such changes mean that an BYDV infection will increase the attraction of the infected plants for aphids, which in turn promotes the spread of the virus. For example, the oat aphid prefers wheat plants that are infected with BYDV over non-infected plants. Research work at the Julius Kühn Institute has shown, among other things, that there is no such preference when healthy plants

VIRUS RESISTANCE REDUCES THE PROPAGATION AND SPREAD OF THE VIRUS IN THE PLANT.

with Ryd2 and plants infected with BYDV are offered as hosts. The conclusion is that Ryd2 not only reduces damage to infected plants, but that it may also reduce the spread of BYDV, as the lack of infection symptoms (including VOCs) makes these plants not especially attractive to the oat aphid.

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