Extract from the German magazine „Innovation“

**The vetch aphid** *(Megoura viciae)* **shown here feeding on the leaf of a field bean** *(Vicia faba)* **is a vector for the persistent Pea enation mosaic virus.**

# DOUBLE TROUBLE: APHID INFESTATIONS AND VIRUS INFECTIONS IN THE FIELD

## Pests which sap strength and cause disease

Regina Kölzsch, Dr. Torsten Will · Quedlinburg

Aphids which are well adapted to their host and the environment are the main vectors for many viruses. Nutrient removal by aphids combined with plant viruses can lead to significant yield losses in arable crops. Consequently, an aphid infestation poses a danger to the crop in more ways than one.

Viruses can be transmitted to plants by different carriers (vectors), of which insects are the largest group. In addition to cicadas, whiteflies and thrips, aphids are responsible for every second virus infection and thus constitute an important vector group. Aphids are able to extract nutrients from plant cells without causing primary damage, thereby enabling the pest insect to remain on the host plant for a prolonged period. They use their piercing mouthparts, known as stylets, to probe the plant and extract nutrients from the plant's vascular system (phloem).

### The virus-vector-host relationship

If a plant carries a virus, it is possible for an aphid to become infected by feeding on any plant cell. This is the case with viruses which spread in the epidermis and the inner mesophyll layers of the plant. Following uptake by a vector, these viruses attach themselves to the inside of the stylet and can be transmitted to a host when saliva displaces the virus particles from their binding site in the stylet. The window for transmission is only short due to a rapid drop in infectiousness and non-persistence.

Viruses that are located within the phloem, which is distributed through the plant inside the vascular bundles, are dependent on the vector (e.g. an aphid) accessing the phloem. Once these viruses have been ingested by the vector, they are transported to it's digestive system and from there to the haemolymph (blood) and finally to the salivary glands. From there, they are redeposited in a host plant. This group of viruses are described as persistent, meaning that the virus-carrying insect remains infectious throughout its lifetime.

If we consider the interaction between plant, virus and vector using the infection of barley by the barley yellow dwarf virus as an example, it becomes clear that in the case of barley, a virus infection strongly influences the defence mechanism inside the plant. Such effect is to suppress the spread of long-distance signals in the plant, which is thought to make the plant more

**Tab. 1: Some examples of the complex interaction between virus, vector and host.**

| Virus | Trans-mission | Vector(s) | Wirtspflanze(n) des Virus |
|---|---|---|---|
| **Barley yellow dwarf virus,** (BYDV) and **Cereal yellow dwarf virus** (CYDV) | Persistent | English grain aphid (*Sitobion avenae*), bird cherry-oat aphid (*Rhopalosiphum padi*), corn leaf aphid (*Rhopalosiphum maidis*) | Oats, barley, wheat, rye |
| **Turnip yellows virus** (TuYV) | Non-persi-stent | Peach-potato aphid (*Myzus persicae*) | Oilseed rape, cauliflower, kohlrabi, black mustard and several others |
| **Beet yellows virus** (BYV) | Semi-persistent | Peach-potato aphid (*Myzus persicae*), black bean aphid (*Aphis fabae*) | Beets |

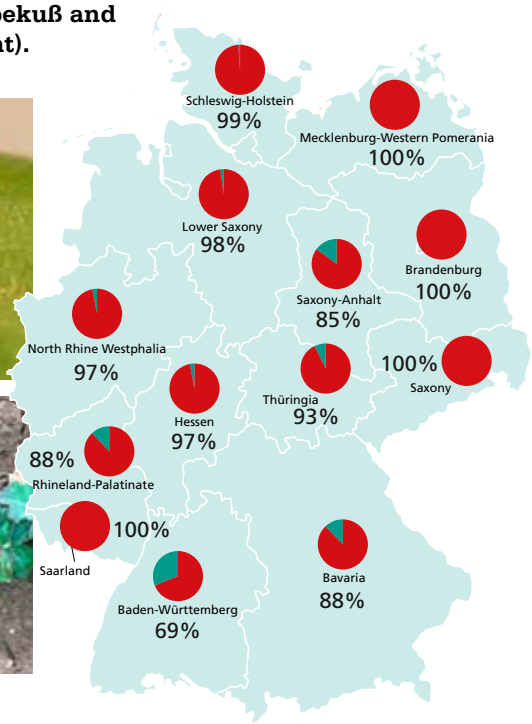
susceptibleto aphids. This effect is not observed in virus-tolerant plants. Furthermore, changes in the plant scent make infected and susceptible plants more attractive to vectors, thereby promoting the spread of the virus.

It depends partly on the virus and partly on the vectors whether a virus infects one or several plant species and how effectively it spreads. The host plant spectrum varies greatly between vector types, ranging from just a few plant species to several hundred.

## Oilseed rape case study

Aphids have gained particularly relevance as a vector for TuYV in oilseed rape. After Whitehorn and colleagues reported a negative impact of neonicotinoids on wild bees in 2012, the implementing regulation for several active ingredients in this insecticide class was amended for oilseed rape and other crops in 2013. Prior to this, seed treatment was considered to be an effective method of controlling the peach-potato aphid (M. persicae) – the main vector for TuYV – in young oilseed rape plants, but has been discontinued as a result of these amendments. After 2014, an increased incidence of M. persicae was observed, along with a rise in TuYV infections. Infected plants show visible reddening at the tips and edges of the leaves immediately after infection as well as reduced leaf size and plant height. Furthermore, a negative impact on yield is also apparent in the form of reduced seed production and an unfavourable change in the concentration of erucic acid and glucosinolates. TuYV is now widespread in oilseed rape cultivation throughout Germany. A similar trend can be observed in adjacent EU countries.

**Fig. 1: : Der TuYV übertragende Vektor *M. persicae* (top left), early spring symptoms in TuYV-infected oilseed rape (bottom right), TuYV incidence in Germany (Habekuß and Will 2018, DLG notifications) (right).**

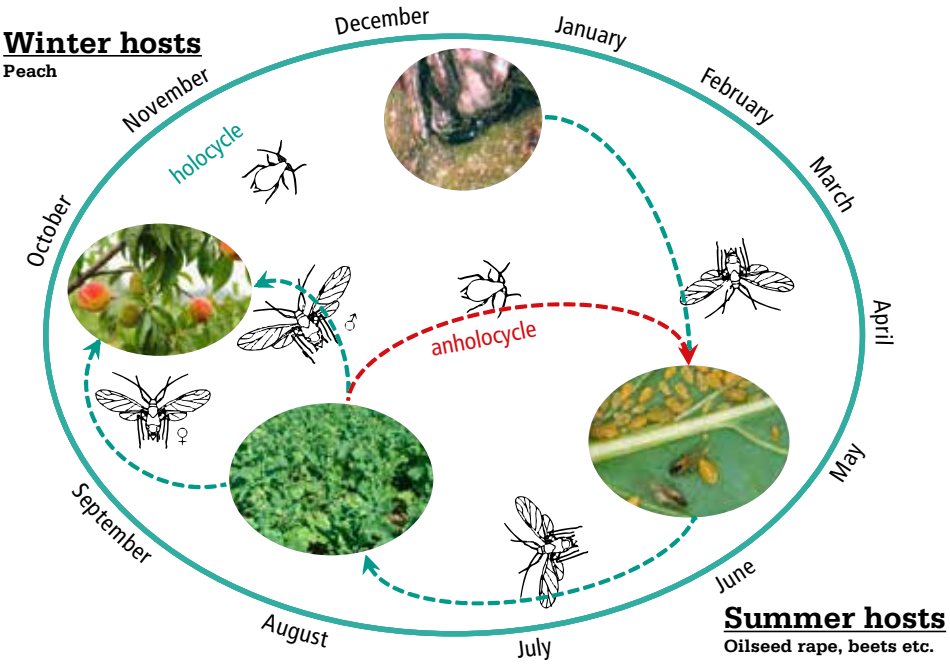



Growers are responding to this increased incidence with a growing number of new TuYV-resistant/tolerant oilseed rape varieties. The underlying genetic resistance suppresses the replication and spread of the virus in young plants at low temperatures. From late spring, as a result of higher temperatures, the virus load starts to rise, although it generally remains below that of susceptible plants. The mechanisms involved in this system are not fully unknown.

## Aphids are adaptable

It's clear from studying *M. persicae* (the peach-potato aphid) why aphids are so effective at transmitting viruses. As its name suggests, one of this aphid's primary hosts is the peach where it lays its eggs to hibernate here. The aphids then reproduce asexually (parthenogenesis) on secondary hosts which include 300 plant species in addition to oilseed rape and beets. As a result, a wide variety of these plant species can become infected with TuYV. So the virus switches back

**Fig. 2: The annual cycle of *M. persicae* (Edgar Schliephake).**




and forth between the hosts as it accompanies *M. persicae*.

In addition to the generation cycle which switches from summer to winter host (holocyclical), adult aphids are able to overwinter on their secondary hosts (anholocyclical). Consequently, particularly high propagation and infestation rates can be observed early in the year. The increasingly mild winters promote the survival of aphids on secondary hosts and furthermore, allow the aphids overwintering as eggs to hatch earlier.

The control of aphids in the field is hampered by insecticide resistance and restrictions on the use of insecticides. It is also evident that reducing aphid infestations by the application of insecticides results in only a slight reduction in TuYV infections, if any.

## Conclusion

Aphids as the most notorious virus-carrying insects show a very wide range of hosts and are extremely adaptable to selection pressure and changing environmental conditions. In view of restrictions on insecticide use and since no aphid-resistant varieties are currently available for many agricultural crops, the use of virus-resistant varieties is an alternative mean of limiting the damage caused by plant viruses.

**Dr. Torsten Will**
Institute for Resistance Research
and Stress Tolerance
Julius Kühn-Institut
Fon +49 3946 47632

**Regina Kölzsch**
Institute for Resistance Research
and Stress Tolerance
Julius Kühn-Institut
Fon +49 3946 47631