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Hop Protection against Harmful Agents in Organic Farming

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Abstract
The beginning of organic hop growing in Czech Republic dates back to 2009. Nevertheless, it has its origin in the early eighties of the 20th century within a research project in the cooperation between Hop Research Institute and Entomological Institute of Czechoslovak Academy of Sciences (Růžička et al., 1986; 1988). Unfortunately, there used to be no demand for organic hops from breweries at that time and therefore we did not continue in this research even though some field trials with predatory mites *Typhlodromus pyri, Amblyseius californicus, Amblyseius cucumeris* or *Phytoseiulus persimilis* were carried out in the nineties and at the beginning of the new millennium (Vostřel, 2001; 2003). Nevertheless, the situation has changed nowadays because there are numerous breweries all over the world, which demand fine aroma organic hops so as to be able to brew high-quality organic beer. It was also the reason why Hop Research Institute persuaded some hop growers in CR

After three years of the necessary temporary period certified organic fine aroma Saazer has been at disposal since August 2012. Whereas damson-hop aphid (*Phorodon humuli* Schrank) is controlled with the help of extract of the tropical plant *Quassia amara* as well as by native predators, mainly aphidophagous coccinellids, predatory mite *Typhlodromus pyri* Scheuten is released to support native populations of acarophagous predators to control two-spotted spider mite (*Tetranychus urticae* Koch). Bio-fungicides Polyversum and Alginure together with limited amount of copper fungicides are use to control the most dangerous disease, downy mildew (*Pseudoperonospora humuli*).

Damson hop aphid (*Phorodon humuli* Schrank) is the most dangerous pest of hops (*Humulus lupulus* L.) in the entire hop growing countries in the north hemisphere. Natural enemies can control it if their abundance is sufficient at the critical time. The role of the individual groups of aphidophagous predators may be various in different countries.
Whereas Aveling (1977) in England found that anthocorids were more abundant than other predatory insects on all sites in England he studied, in most of the other countries aphidophagous coccinellids are the main predators of *P. humuli* (Benker, 1997, Campbell, Cone, 1994). Zelený et al. (1981) monitored the occurrence of aphidophagous predators in the 1970th. They found out that aphidophagous fauna in hops is not specific. It only has some specific characters without differing too much from other agrocoenoses in the western Palearctic sub-region. Two-spotted ladybird (*Adalia bipunctata*) was the most numerous species among Coccinellidae at that time. Vostřel (1990) studied the development of *P. humuli* population, factors of its regulation and possibilities of their utilization within IPM in the 1980th. At that time *Cocinella septempunctata* was of the main importance followed by *A. bipunctata, Propylea quatuordecimpunctata* and *Coccinella quinquepunctata*. Other Coccinellid species were of much less importance. Růžička et al. (1986, 1988) found out that aphidophagous coccinellids, especially adults of the very common species *C. septempunctata* were able to control *P. humuli* in an experimental hop garden.
In the last years the spectrum of aphidophagous coccinelids has changed considerably in Bohemian hop gardens. It was caused by invasion of Asian harlequin ladybird *Harmonia axyridis*. Whereas, in the period before its invasion native species *C. septempunctata*, *A. bipunctata* and *P. quatuordecimpunctata* used to be the dominant predators of damson hop aphid, *H. axyridis* has been the most frequent ladybird species in Zatec (Saaz) hop growing region nowadays (Vostřel, 2015).
Lace-wings (*Chrysopidae*), hover flies (*Syrphidae*), gall midges (*Cecidomyidae*) and anthocorid bugs (*Anthocoridae*) represent other groups of predatory insects, which share in the control of damson hop aphid. Some flowers (e.g. Phacelia) are seeded to attract predators and augment their population density in hop gardens. If aphids become more numerous and population density of aphidophagous predators is too low to control them, extract from a tropical plant, famous for its aphidophagous effect, *Quassia amara* is brushed of sprayed at hop plants. Another plant insecticide, which is commonly recommended to control aphids and spider mites in organic hops, is Rock Effect. It is extract from *Pongamia pinnata*

Predatory mite *Typhlodromus pyri* Scheuten is released to support native populations of acarophagous predators to control **two-spotted spider mite** (*Tetranychus urticae* Koch).

Our experience hitherto with predatory mite *T. pyri* can be summarized in the following way:

T. pyri seems to be a suitable bio-agent for the control of *T. urticae* on organic hops. Nevertheless, optimal release rate is still questionable. It is impossible to determine it in a uniform way as it depends on a location of a hop garden as well as on the population density of *T. urticae*. Commonly we can say if there is no focus of over-wintering females and if there was not an outbreak of this pest at the end of the previous season, we can recommend releasing 1-2 females per plant (crown), i.e. 6-7,000 ex./ha. Otherwise, it is necessary to increase the rate on the standard number of 5 ex./plant (crown), i.e. 16,000 ex./ha.
After reaching the natural balance between acarophagous predators including native natural enemies of spider mites (acarophagous thrips, predatory bugs, tiny lady birds *Stethorus spp.*, gall midges *Feltiella acarisuga* and others) we suppose that another release would be necessary only if the number of spider mites reach the value of economic threshold (5 mobile stages/leaf) and predatory mites and/or native acarophagous predators will be present only in low densities.
Predatory mite *T. pyri* is able to over-winter in Bohemian hop gardens. The over-wintering generation can significantly reduce population density of *T. urticae* in the following season as it was confirmed in some experimental plots. Other research should be aimed at the improvement of over-wintering conditions, as we must realize that harvested hop bines are transported at a stationary picking machine on the contrary to orchards, where this species is commonly used to keep spider mites under the economic threshold.

Downy mildew (*Pseudoperonospora humuli*) is the most important fungi disease of hop plants not only in Czech Republic but also in many other countries of the world where hop is grown. Successful protection against this disease is based on the elimination of primary infection in spring. Bio-fungicide Polyversum, which induces defending responses in plants, is used for this purpose. It contains fungi parasitic microorganism *Pythium oligandrum* naturally occurring in European soils. The main effect consists in mycological parasitism. Its application is recommended in the time when hop shoots start to emerge from the soil after spring pruning. Later during the vegetation bio-fungicide Alginure containing extract from algae, plant amino acids and potassium phosphite is applied together with copper fungicides, whose dose must not exceeded 6.0 kg/ha/year.

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Fig. 1: Primary infection of downy mildew (*Pseudoperonospora humuli*) in the form of spikes.

Fig. 2: Hop leaves and cones damaged by damson hop aphid (*Phorodon humuli*).

Fig. 3: Two spotted spider mites (*Tetranychus urticae*) can cause severe damage of hop plants leading to their defoliation.

Fig. 4: Developmental stage (deutonymph) of *Typhlodromus pyri*.

Fig. 5: Predatory mites *T. pyri* are delivered by Biola Chelčice in strips of cloth containing on average five gravid females.

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