

# PROTECTION OF THE GRAPEVINES

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# INTRODUCTION

## Why the need to protect grapevines?

Grapevines have a unique importance for humans since ancient times. Grapes are one of the greatest fruits of nature and wine is a special kind of food. Some people are cultivating vines to make living, while others just like to enjoy their fruits in one form or another. Usually, we want to produce as many high quality grapes as possible. Unfortunately, grapevines are - like any other plant species - exposed to environmental influences, diseases and insects. Some of the pathogens and insects can threaten the existence and production capability of grapevines, while others harm vines only occasionally and in to a minor extent. For now, we cannot completely avoid the



protection of the grapevines against diseases and insects. To protect the grapevines, we rely on the new findings from the fields of chemistry, biology, plant physiology and mechanical technology. But in some cases, we are still powerless against the nature.

Over the decades, the globalization and increased mobility allow increasing number of insects and diseases to cross national and continental borders. Desire for more crops, rapid development of the vineyards, excessive fertilization and environmental changes are reducing the natural resistance of the grapevines, and make them more susceptible to certain diseases and pests. Development of numerous diseases and insects is, namely, directly linked to the production technology changes. As a result, a lot of work still needs to be done in order to reduce the need of grapevine protection through a direct chemical use on diseases and injuries.

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- ❖ Vines have a unique importance for humans since ancient times.
  - ❖ Vines are like any other plants exposed to environmental influences, diseases and pests.
  - ❖ Development of numerous diseases and pests is directly linked to the production technology.

# WHO CAN THREATEN GRAPEVINES?

Grapevines are, like any other plant species, exposed to environmental influences, and several pests. Plants can be affected by living (biotic) and non-living (abiotic) factors. As a result of those factors, the key processes in the plants are disrupted, such as: photosynthesis, respiration, transportation of water and nutrition, growth, reproduction, etc. Noticeable changes on an infected plant are called symptoms. Symptoms can be well noticeable, as necrosis shoots, leaf mottle and yellowing or less noticeable, as in the case of the presence of fungal mycelias, carpophores spores, and bacterial exudes, etc.

Non-living factors are unfavorable weather conditions (cold, heat, drought, heavy rains, hail, strong winds), lack or excess of nutrients, poor soil conditions (compaction of the soil, inadequate pH), toxic substances in the soil, water and/or air, inappropriate treatment of the plants (eg. phytotoxic of the pesticides), etc.



Hail damage in vineyard



Sunburn damage on grapes

Living factors, which threaten plants species, are fungus, fungi-like organisms, bacteria, phytoplasma, viruses and viroids. Pests are causing deformities on plant leaves and shoots, neoplasms, wilting and growth retardation. Grapevines are threatened by several fungal, viral and phytoplasma diseases, as well as bacterial diseases, insects and mites.

## Grape disease

### Fungal disease

Fungal diseases are the largest group of plant pathogens. After an initial infection, they spread with the wind and the rain. Insects and other organisms can also be transmitters of the fungal diseases. Most common fungal diseases on grapevines are: downy mildew, powdery mildew, gray mold, black rot, and phomopsis cane and leaf spot.



Downy mildew on the grape

### Bacteria

Bacteria are simple single-celled organisms that grow rapidly. They penetrate into the vines through natural openings of vines, or through vine wounds. Most common signs of bacterial infections are inflammation of the tissues, and formation of cancer wounds. Most known bacterial vine diseases are: Happy disease, Crown gall and Pierce's disease.



Crown gall on grapevine

## Phytoplasma

Phytoplasmas are according to the cell structure similar to the bacteria. They live in plant phloem tissue. Some of the most known phytoplasma grapevine diseases are: Flavescence dorée (FD), Bois Noir (BN), Grape leaf rust mite and Grapevine yellows (GY).



Flavescence dorée in vineyard

## Viruses

Viruses are microscopic pathogens living inside the living cells. After entering into the vines, they spread into all underground and above ground plant parts. In the nature, viruses are transmitted through vectors – insects, mites and nematodes. Most known viruses of grapevine disease are: Feanleaf virus (GFLV) and Leafroll (GLRaV-1, GLRaV-2, ...).



Grape leaf roll virus

## Grape insect and mite pests

Various insects and mites are jeopardizing vines, but only some of them are responsible for the economic losses. Insects and mites are making direct and indirect damage. They eat underground and above ground vine organs and are transmitters of fungal, virus and phytoplasma diseases. Insects and mites that threaten grapevines are: butterflies, cicadas, scale insects, aphids, thrips, beetles, mites, etc. One of the most dangerous cicadas of grapevine is American grapevine leafhopper, which is the transmitter of Flavescence dorée.



Grape leafhopper



European grape berry moth

## Weeds

Weeds are plants that are not desirable in the fields of agricultural plants. They are competing with the plants, planted for crops, for water, nutrients, light and space. If they are not properly controlled, they can reduce the quality and quantity of the yield in the vineyard. In addition, weeds can be hosts of several pathogens and pests, and make problems during the harvest.



Weed in the vineyard

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- ❖ Grapevines are exposed to environmental influences, and several types of diseases, and pests.
  - ❖ Abiotic and biotic factors can affect structure and/or function of the plants.
  - ❖ Most damage on grapevines is caused by fungal diseases, and grape insect and mite pests.



# PROTECTION OF GRAPEVINES

Protection of plants against the diseases, insects and weeds has a long history. Since man has started to cultivate plants, he was searching for ways to reduce the negative impact on those plants. Traditional methods, which were developed through testing and observation, were passed from generation to generation and are still the pillar of the pest control, which is now complemented with modern techniques. Despite all of the modern techniques, the winegrowers are still facing the same problem each year: **how to properly protect vineyards.**

There are several traditional and modern techniques that winegrowers can choose to protect grapes. For the best protection of grapevines, a combination of several methods should be used, which will give the best results in given circumstances.

In general, the chosen methods should:

- minimize harmful effects on human health,
- minimize harmful effects on non-target organisms (like fish, birds, bees, ...),
- minimize harmful effects on the environment,
- be durable,
- be economically efficient, and
- be feasible and as simple as possible for the winegrowers to conduct them.

**Integrated pest management (IPM)** has proved to be the most economically efficient and environmentally friendly approach to the pest management. IPM includes several direct and indirect methods for pest control.

Some of the **indirect methods** of pest control are:

- variety selection,
- fertilization,
- irrigation,
- pruning methods,
- land selection, etc.

**Direct methods** of pest control include:

- physical (mechanical control - tillage, mulching, flooding; thermal control; electromagnetic control),
- bio-technical (use of sexual confusion, food traps,...),
- biological (use of predators, parasitoids, pathogens and competing pests) and
- chemical (use of pesticides) control.

Pruning of the grapevines



Pheromone trap



Grapevines being sprayed

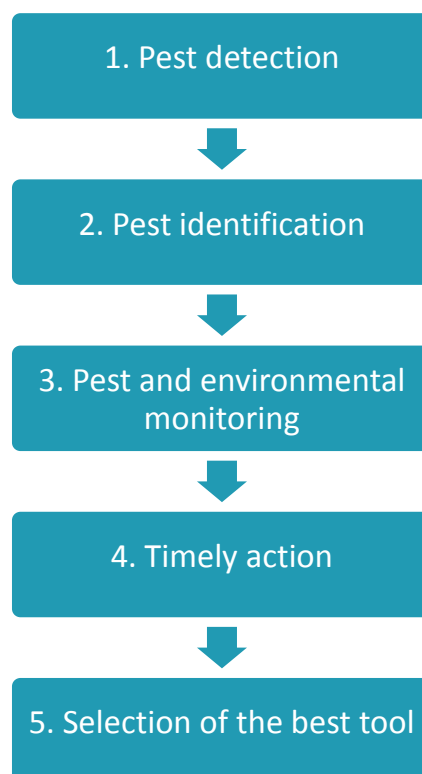
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- ❖ Traditional methods of pest control are now complemented with modern techniques.
  - ❖ Grapevine pests control should include a combination of several methods.
  - ❖ IPM is economically efficient and environmentally friendly approach for pest management.

# INTEGRATED APPROACH

Integrated production is a nature-friendly method of grape production. The main aim is to produce high quality grapes on economically sustainable way while reducing the negative impact on the human health and on the environment. Since vineyard represents a special habitat for several living creatures and since the diversity of those creatures depends on the vineyard treatment methods, the Integrated Pest Management approach aims to control only those pests which cause negative economic impact.

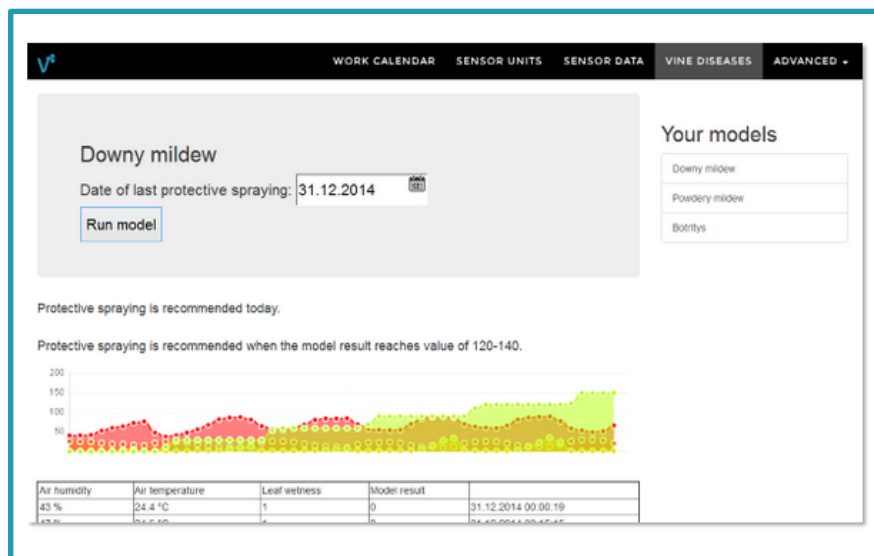
According to the United Nations, Integrated Pest Management is: *"the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms."*

Since the development of various pests and weeds of grapevines depend on production technology, it is wise to consider the indirect methods of pest control even before setting up a vineyard. With indirect methods, such as variety selection, fertilization and irrigation, winegrowers can reduce the risk of infections and therefore the need to use direct methods, such as chemical control. Integrated pest management control can be divided into 5 steps, which winegrowers can follow in order to optimize the pest management control.



If we want to reduce the damage, caused by the present diseases, insects and weeds, and prevent the introduction and spreading of the new ones, we have to know the root of the problems. The first step in pests control is the detection of injuries and symptoms, followed by the determination of the causative organism (identification). Only after the correct identification of causative organisms we can select the right tool to control them. Wrong or late detection of the disease and insect symptoms can cause huge economic losses. In order to determine the health status of the plants, we have to regularly monitor the crop. Winegrowers should know about all of the development stages and growth characteristics of the grapevines, as well as the development stages and injuries of at least most threatening pests of the grapevines. With a timely detection of the problems, we can reduce the need of pesticide use. The repression of pests is more efficient when the population is smaller and therefore manageable.

Each winegrower should know which pests are presenting the real danger to his grapes and which are irrelevant from the economic point of view. The major economic damage occurs when the value of crop losses exceed the costs of repression. After identification of the pests, winegrowers should monitor pests and environment data, since a lot of the most dangerous diseases of grapevine depend on the environmental conditions. Winegrowers can get weather information from various sources, such as from the websites, on on-site weather stations, etc. to estimate the critical timing of an infection. Since act on time is crucial for the best pest control, several decision support systems were developed over the past years. One of them is [eVineyard application](#) that advises you on when to take the preventive actions against vine diseases, based on the weather data, past actions of winegrower, terroir and the vineyard characteristics. With this application, winegrower can grow better grapes with fewer resources and in the most environmentally friendly way possible.



Downy mildew prediction model

After the winegrower is armed with available environmental data and knowledge, and the determination of the critical time of infection; wise selection of the tool to fight the pests is necessary. Winegrower can decide for one method, or for a combination of several methods of pest control. Direct methods of pest control should be use: either physical (mechanical control - tillage, mulching, flooding; thermal control; electromagnetic control), bio-technical (use of sexual confusion, food traps,...), biological (use of predators, parasitoids, pathogens and competing pests) or chemical (use of pesticides) control. Since the majority of winegrowers tend to use chemical substances to control the pests, we will focus on a chemical pest control in the next section.

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- ❖ Monitor the crops to detect injuries and symptoms early on.
  - ❖ Correct identification of causative organisms allows grower to choose the right pest control mechanism.
  - ❖ Timely detection of problems reduces the need for spraying (and saves money!).
  - ❖ Observation of the crop, weather forecasts, and disease and pests prediction models like eVineyard help winegrowers to protect vineyards.

# CHEMICAL PEST CONTROL

Chemical pest control is a control of insects, plant pathogens and weeds by chemical plant protection products. Plant protection products are often referred as pesticides - all chemical substances that protect plants or plant products against insects, weeds and diseases. The term pesticide may also refer to products for non-agricultural use.

According to chemical structure, the pesticides can be: organic, inorganic, synthetic or biological. Organic pesticides usually contain carbon in their chemical structure and are more complex than inorganic pesticides which do not contain carbon. Most of the pesticides that are in use are organic – synthetic or biological. Biological pesticides are derived from naturally occurring sources such as plants, algae, fungi or bacteria. While synthetic pesticides are made artificially by chemical synthesis.

**Plant protection products (PPP)** are a wide range of substances with different names and functions. Usually, they are divided into groups, depending on which kind of pests can be suppressed by them.

Pesticides according to the pest that they control:

- acaricide substances to control mites,
- bactericides substances to control bacterial pathogens,
- fungicides are substances to control fungal diseases,
- herbicides are substances to control weeds,
- insecticides are substances to control insect pests (insects),
- limacides are substances to control snails,
- nematicides are substances to control nematodes, and
- rodenticides are substances to control rodents.

Those pesticides are further divided into multiple subgroups; within each subgroup, there are substances with similar chemical structure or similar mechanism of action against pests. Winegrowers mostly use fungicides, sometimes also insecticides, acaricides, and herbicides.



Spraying of the grapevines

## Fungicides

Fungicides are chemical substances that hinder or completely stop the development of the fungal diseases on the cultivated plants. They can be used for foliage spraying, watering, irrigation, seed disinfection, and as fungicidal paste or infusion. According to their operation mode, we divide them into three different groups: contact, systemic and locally systemic fungicides.

The **contact fungicides** prevent an infection with the formation of a coating on a plant surface which then destroys disease spores and/or prevent their emergence. Since they prevent infections only on a sprayed surface, a good application of spray is crucial. Application of contact fungicides must be repeated frequently, because the newly accrue leaves are not protected. In addition, rain washes off the contact fungicides.

The **systemic fungicides** enter into the plant through the leaves or roots and are redistributed through the plant vascular system to the other parts of the plant. Most of the systemic fungicides are moving upwards in the plant. The advantage of the systemic fungicides against contact is the fact that the rain can't wash them off the plant once the plant has absorbed them, as well as the fact that they protect also newly accrue parts of the plant.

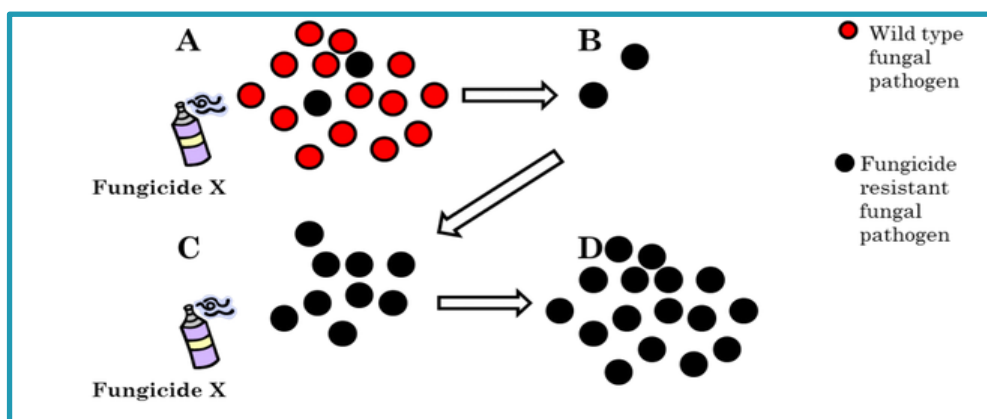
**Locally systemic fungicides** also enter into the plant, but in comparison to systemic fungicides, remain in the vicinity of the application site and cannot move to the distant parts of the plant. That's why they can prevent development of the disease only near the sprayed surface. Since the rain cannot wash them off, they protect plants for a longer period of time. Another kind are translaminar fungicides which get redistributed from the upper to the lower (not sprayed) leaf surface.



Spraying of the grapevines

Most fungicides prevent the germination of the fungal spores and/or disable their development. Some systemic fungicides are curative, which means that they can stop further development of the pathogens once the pathogens have already infected the plant. Since curative fungicides can stop infection only shortly after the infection has occurred, the timely pesticide application is crucial. Fungicides are primarily used to prevent the infection when the probability of infection is high and the environmental condition accelerates the development of the diseases. Modern decision support systems like [eVineyard](http://www.evineyard.com) can alert you about such conditions, so you can time the spraying in a more punctual way. If infection has already occurred on plant, preventative chemical protection is ineffective and uneconomical, while the curative chemical protection is more expensive.

While selecting fungicides we have to consider the risk of the resistance development, meaning that the fungus may develop resistance to a certain kind of fungicides and is not affected by it. Fungus develops resistance faster for fungicides with a very specific and narrow spectrum of activity.



Development of fungicide resistance in a fungal pathogen population

### Insecticides and acaricides

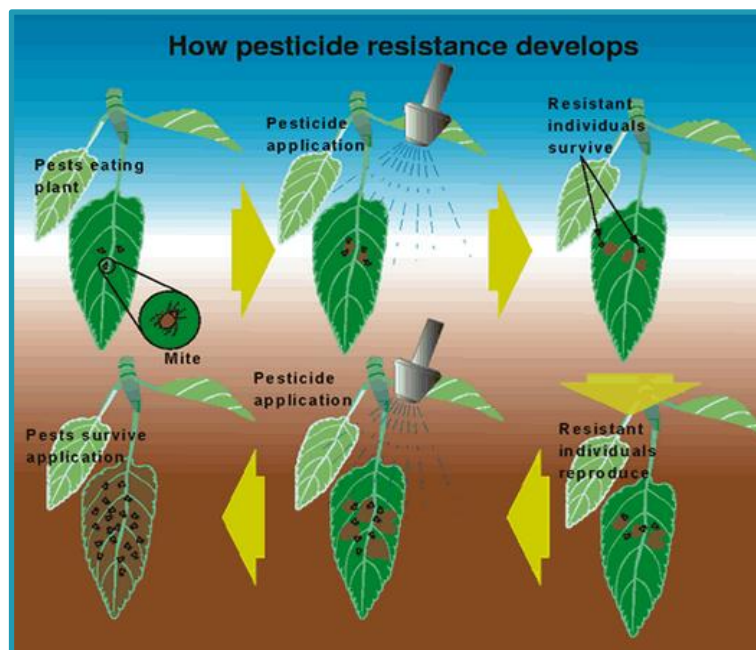
Insecticides are chemicals to control insects, while acaricides controls mites. Insecticides and acaricides have similar characteristics and modes of actions; therefore we will describe only insecticides, but keep in mind that the descriptions also apply to acaricides.

Insecticides can be divided into two major groups: contact and systemic. The **contact insecticides** do not enter in the plant, so they can protect only sprayed surface of the plant. While **systemic insecticides** enter into the plant and travel to other (not sprayed) parts of the plant. These insecticides function efficiently to control the insects which suck nutrients from the sprayed plant. The advantage of the systemic insecticides is that the rain cannot wash them off the plant, as well as the fact that they protect also newly accrue plant parts. There are also insecticides that do enter into the plant, but do not travel in the plant.



According to the mode of action, insecticides can kill pests in several different ways: they either enter into the body of the insect through the epidermis, gastrointestinal tract and/or through respiratory track of the pests. Some insecticides act primarily on insect eggs, some predominantly on the larvae and some on the adult insects. A special group of insecticides are inhibitors of insect development, which hinders the molting of insects.

Just like fungus can develop resistance to the fungicides, also insects can develop resistance to the insecticides. Therefore a careful use of pest protection products is extremely important. Otherwise, next year or year after, the same pesticide will no longer protect grapevines against the insects.



Pesticide resistance development

## Herbicides

Herbicides are chemicals that control unwanted weeds within agricultural crops surfaces, as well as on non-agricultural surfaces. Several different herbicide groups exist and can be grouped based on their application methods and spectrum of actions.

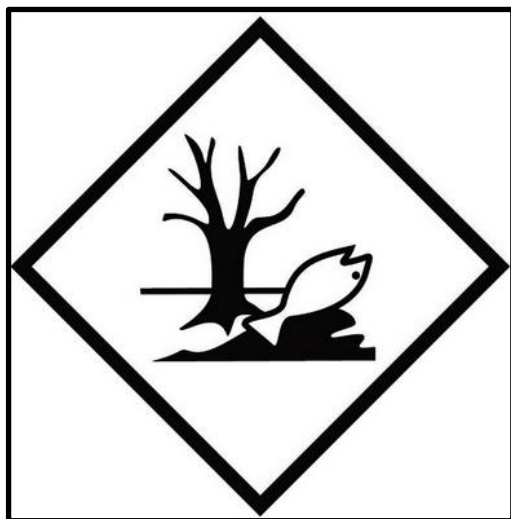
<b>Application site</b>	Foliar and ground
<b>Mode of action</b>	Contact and systemic
<b>Spectrum of action</b>	Selective and non-selective

Herbicides function the best when they are sprayed during an active weed growth and/or under the environmental conditions which allow good growth. If the weeds are under stress (extreme temperatures, drought, etc.), then herbicides do not function well. **Foliar herbi-**

**cides** have to be applied in the so called post-emergence time (after the weed started growing), because they enter into the plants through the leaves. **Ground herbicides** are sprayed to the ground; they enter into the weeds through the roots or weeds absorb them during the germination. **Contact and systemic herbicides** work in the similar ways as previously described contact and systemic fungicides, with the difference in the fact that herbicides destroy sprayed plants (weeds). According to the spectrum of the action, there are **selective and non-selective herbicides** in the existence. Most herbicides used in agriculture are selective herbicides, which affect only certain weed species and do not harm cultivated plants.

### Negative effects of chemical pest control

Pesticides are a special group of chemicals used for the control of the insects, weeds and diseases. Although, they may be very useful in pest control, they can cause chemical damages to the other organisms (like plants, animals and humans). If the organism is exposed to a sufficient quantity of pesticides in such a way that pesticides can enter into the body – in case of a human that happens through the skin, or through ingestion and inhalation. Pesticides also have negative effects on the environment; they can pollute air, soil and water, and harm non-target pests, such as bees. Inappropriate use of pesticides can lead to the **negative and irreversible consequences** for humans, animals, and for the environment.



Environmental hazard symbol



Acute toxicity hazard symbol

## Application techniques

Method and quality of application has a big impact on the performance of the plant protection products. Through appropriate application, winegrowers contribute to reduction of pesticide consumption and pollution of the environment. Plant protection products for the grapevine protection are usually applied with spraying. A support medium for such technique of application is water. Water consumption has to be adjusted to the pesticide's mode of action, and to the crop conditions. Incorrect dosage of pesticides may lead to poor protection of the plants, or to excessive environment pollution. On the other hand, the excessive amounts of water can cause drainage drift through the leaves of plants, and consequently the losses of the spray. Therefore it is extremely important that winegrowers know how to calculate the **required formulation** of pesticides, dependent on the amount of water they use and the size of their vineyard. Great help for calculation of the required quantity of pesticide use is [eVineyard calculator](#). In vineyards, the average water consumption varies between 100 and 1500 l/ha. For the performance of the spraying, it is important to properly determine the required amount of water, calculate the right amount of pesticide dose, and choose the right nozzles. When spraying we must also take in account the direction and the speed of the wind.



Pesticides can be applied to the target surface in various ways. There are several different application methods bound to the size of the pesticide drops, such as: spraying, fogging, coating and dusting. Winegrowers can choose among various spraying devices, for the application of the plant protection products, depending on the size of the vineyard. When working with the sprayers, a precise application of pesticides is important!

When applying the pesticides, we should be aware that most of the pesticides leave residue on the crop, therefore it's necessary to consider several preventive measure against

contamination. After spraying, a restricted entry interval (REI) should be ensured. REI is the amount of time during which no one is allowed to enter into the treated area, since pesticide residue levels can endanger peoples' health. That is the time in which the pesticides degrade in such a way that they are no longer harmful for human and animal health. REI is listed on the pesticide label, as well as the pre-harvest interval (PHI), which determinates the last time when pesticide can be applied before the harvest. The PHI is closely related to the residue limits, or the maximum residue limits (MRL). MRLs determine acceptable levels of the permitted pesticide residue in the food, which can be ingested in one day without any harmful effects on human health. Winegrowers should pay special attention to the pre-harvest interval since most of the fungicides can affect the fermentation and therefore the taste of a wine. The presence of the fungicides in the grape "juice" can kill or inhibit yeast, since they are single-celled fungi. Different commercial pesticides have different length of the above listed intervals; they depend on the degradation period of the specific pesticide.

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- ❖ Chemical pest control - controls of the pests, diseases and weeds by chemical plant protection products (PPPs).
  - ❖ Winegrowers mostly use fungicides, sometimes also insecticides and accaricides, or herbicides.
  - ❖ Plant protection products can have negative effect on the human and animal health, as well as on the environment.
  - ❖ Appropriate application of PPPs reduces pesticide consumption and pollution of the environment.
  - ❖ It is crucial to know to how to calculate the required formulation of pesticide and water use!

# CONCLUSION

Since ancient time, humans have cultivated grapes for food and wine. Grapevines are like any other plant species exposed to the environmental influences, diseases and pests, which can threaten production capability and existence of the grapevines. Despite all of the development and the new technologies, we still cannot completely avoid the necessity to protect the grapevines against the diseases and pests. The vines are threatened by several fungal, viral and phytoplasma diseases, as well as by bacterial diseases, insects and mites. Protection of the plants against the diseases, insects and weeds has a long history. **Traditional methods**, which were developed through testing and observation, are now **complemented with modern techniques**. A currently widely recommended way due to its efficiency is so called integrated pest management (IPM) approach, which combines several traditional and modern techniques. IPM approach consists of 5 stages: detection of pest, identification of pest, pest and environmental monitoring, on-time action, and selection of the best tool. Even though there are several different methods of pest control, the majority of the winegrowers tend to use chemical substances to protect their grapes. Chemical substances that protect plants are called plant protection products or “pesticides”. In one growing season, the winegrowers use a whole range of pesticides, from fungicides, insecticides and acaricides, to herbicides, to protect their grapevines. In terms of protection, the systemic pesticides (fungicides, insecticides and acaricides) are probably the most effective in general, but that does not mean that only systemic pesticides may be used. However, systemics can protect also newly grown plant parts, that were not sprayed, and the rain cannot wash them off after the plant has absorbed them. On the other hand, the ability of systemic pesticides which can travel up and down the plant parts means that they eventually end up in the grapes and it’s completely impossible to wash them off. This means that the grapes can be toxic for the human and animal health, if the pesticides are not properly used. Many winegrowers are already aware that the pesticides affect grapes and thereby the products of the grape, like wine. Because of that, they are looking for new (old) ways to protect their grapevines. This goes in hand with the increased consumer’s awareness for a more **sustainable wine production**. After all, it’s all about the demand.





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