eVineyard

Protection of the grapevine

An overview of pest protection options for the grapevine

ebook by eVineyard team

Content

Introduction

Grapevines have a unique importance for humans since ancient times. At first, grapes have been harvested as a source of food. While the first evidence of domesticated grapes dates from about 6000 BC located in southeastern Georgia, according to the archaeologists. Different parts of grapevine can be used as nutrition and medicine. Nowadays grapes can be eaten fresh, dried as raisins, or can be used for making juice, wine, jam, jelly, and vinegar. Grape seeds are used for making grape seed extracts and grape seed oil, while grape leaves are also used in cooking.
While most people like to enjoy eating grapes in one form or another, others are cultivating vines to make a living. Therefore, producing high-quality grapes is in the interest of all.

Unfortunately, grapevines are - like any other plant species - exposed to environmental influences, diseases, and insects. While some of the pathogens and insects can threaten the existence and production capability of grapevines, others harm vines only occasionally and into a minor extent.

“As grapes are one of the best fruits of mother nature, wine is a special culinary delight.”

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 nature.

Over the decades, the globalization and increased mobility allowed an increasing number of insects and diseases to cross national and continental borders. The desire for more crops, a rapid development of the vineyards, excessive fertilization, and environmental changes are reducing the natural resistance of the grapevines, and making them more susceptible to certain diseases and pests.

Development of numerous diseases and insects is, namely, directly linked to the changes in production technology. As a result, a lot of work still needs to be done in order to reduce the need for grapevine protection through a direct chemical use on diseases and plant wounds.

What threatens GRAPEVINES?

As mentioned before, grapevines are, like any other plant species, exposed to environmental influences, and 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 mycelia, carpophores spores, and bacterial exudes, etc.

Non-living factors

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 air, inappropriate treatment of the plants (eg. phytotoxic of the pesticides), etc.

Sunburn damage on grapes, photo by Tablas Creek Vineyard

Living factors

Living factors, which threaten plants spices, are: fungus, fungi-like organisms, bacteria, phytoplasmas, 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.

Pierce's diseases on grape leaf, photo by APS

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 leaf, photo agric.wa.gov.au

Further reading

To protect grapevines against fungal diseases, determination of the right timing and pesticide selection is crucial. And this can only be achieved by knowing the disease cycle and its symptoms. Check the the links below on the most common grapevine fungal diseases.

- Downy mildew primary infection
- Downy mildew secondary infection
- Powdery mildew
- Gray mold
- Black rot
- Phomopsis cane and leaf spot
- Anthracnose of 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, photo by Penn State University

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, photo by flavescencedoree.jimdo.com

Viruses

Grape leaf roll virus (GLRaV4), photo by Oklahoma State University

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

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.

Weeds in the vineyard, photo by Ohio State University

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 aboveground 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.

American grapevine leafhopper, photo by wikimedia commons

European grape berry moth, photo by AgroAtlas

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 all negative impacts 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 (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.

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

Indirect methods

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

Pruning of vines, photo by Finger Lakes Grape Program on youtube

Direct methods

- **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

Trap in the vineyard, photo by Paul Chinn, The Chronicle

Mulching, photo by Clemens technologies

Integrated approach

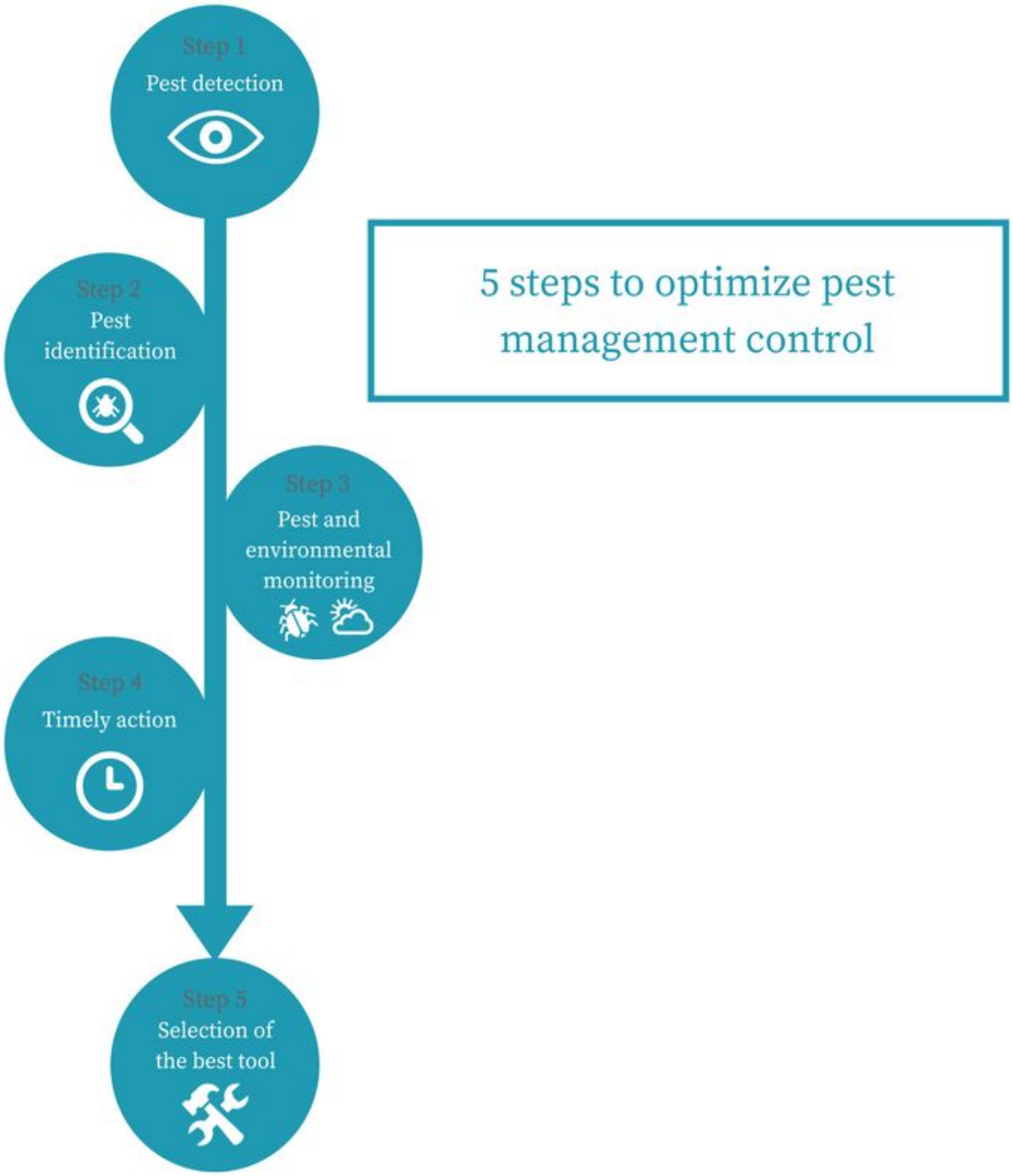
Integrated production is a nature-friendly method of grape production. The main aim is to produce **high-quality grapes** on the **economically sustainable way** while **reducing the negative impact** on the human health and on the environment.

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 the negative economic impact. According to the United Nations, Integrated Pest Management is:

Ladybug on on a tiny grape cluster, photo by tripadvisor

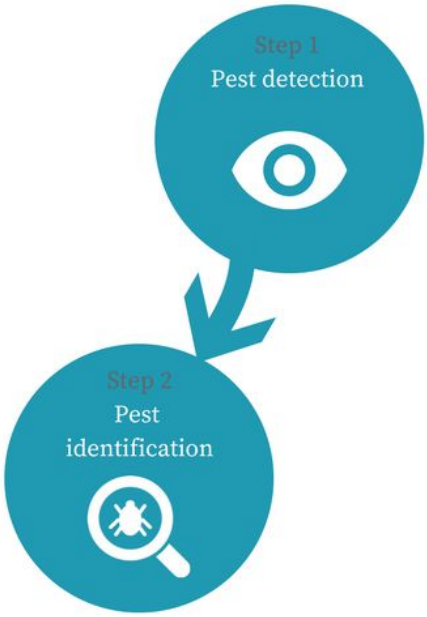
> *The careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health 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.



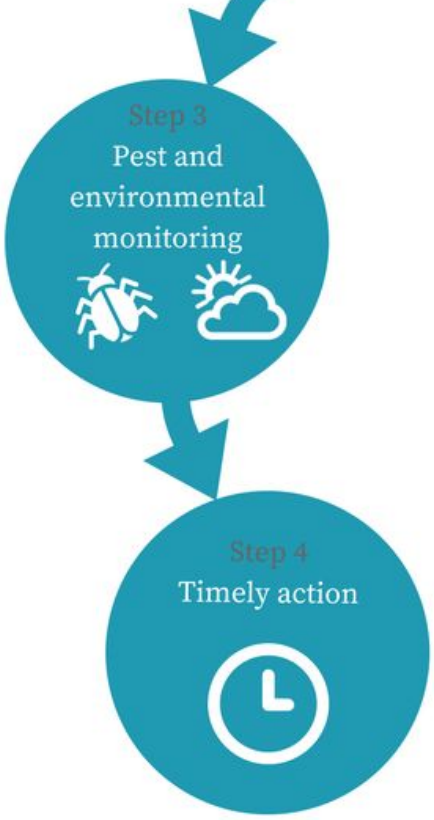
If we want to reduce the damage, caused by the present diseases, insects, and weeds, and prevent the introduction and spreading of the new ones, we have to know the root of the problems.

The first step in pest 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 the most threatening grapevine pests. With a timely detection of the problems, we can reduce the need for pesticide use. The repression of pests is more efficient when the population is smaller and therefore manageable.



Further reading

- Overview of Grapevine Structure and Function
- Why the need to calculate growing degree days in the vineyard?



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 exceeds 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 acting on time is crucial for the best pest control, several decision support systems were developed over the past years. One of them is the **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.

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. Following direct methods of pest control can be used:

- **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.

Because the majority of winegrowers tend to use chemical substances to control pests, we will focus more on a chemical pest control, in the next section.

Further reading

- Pesticide use, and their impact on the fruits
- Cover cropping: alternative to herbicide use in the vineyard
- Pest management control

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” i.e. 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 to control mites,
- bactericides to control bacterial pathogens,
- fungicides to control fungal diseases,
- herbicides to control weeds,
- Insecticides to control insect pests (insects),
- limacides to control snails,
- nematicides to control nematodes, and
- rodenticides 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. Since winegrowers mostly make use of fungicides, insecticides, acaricides, and herbicides description of these plant protection products follow.

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 foliar 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.

Sign for prohibition of entry into the vineyards because of spraying, photo by wiki

The **contact fungicides** prevent an infection with the formation of a coating on a plant surface which then destroys disease spores and/or prevents 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.

Summer spraying in the vineyard, photo by Bastianich winery

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 the 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 of fungicides is **translaminar fungicides** (semi systemic) which get redistributed from the upper to the lower (not sprayed) leaf surface.

Most fungicides prevent the germination of the fungal spores and/or disable their development. Some systemic fungicides are curative, which means that they can

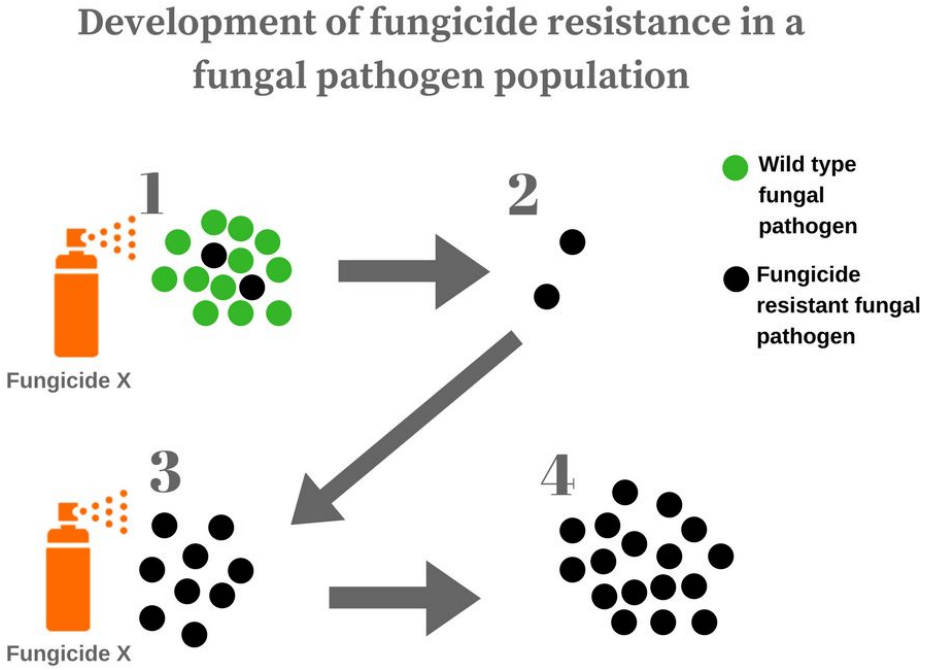
Snapshot from the infographics on "pesticide use", infographic by eVineyard

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** can alert you about such conditions, so you can time the spraying in a more punctual way.

If the infection has already occurred on the plant, preventative chemical protection is ineffective and uneconomical, while the curative chemical protection is more expensive.

When 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. The fungus develops resistance faster for fungicides with a very specific and narrow spectrum activity.



Insecticides and acaricides

Insecticides are chemicals used to control insects, while acaricides control 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.

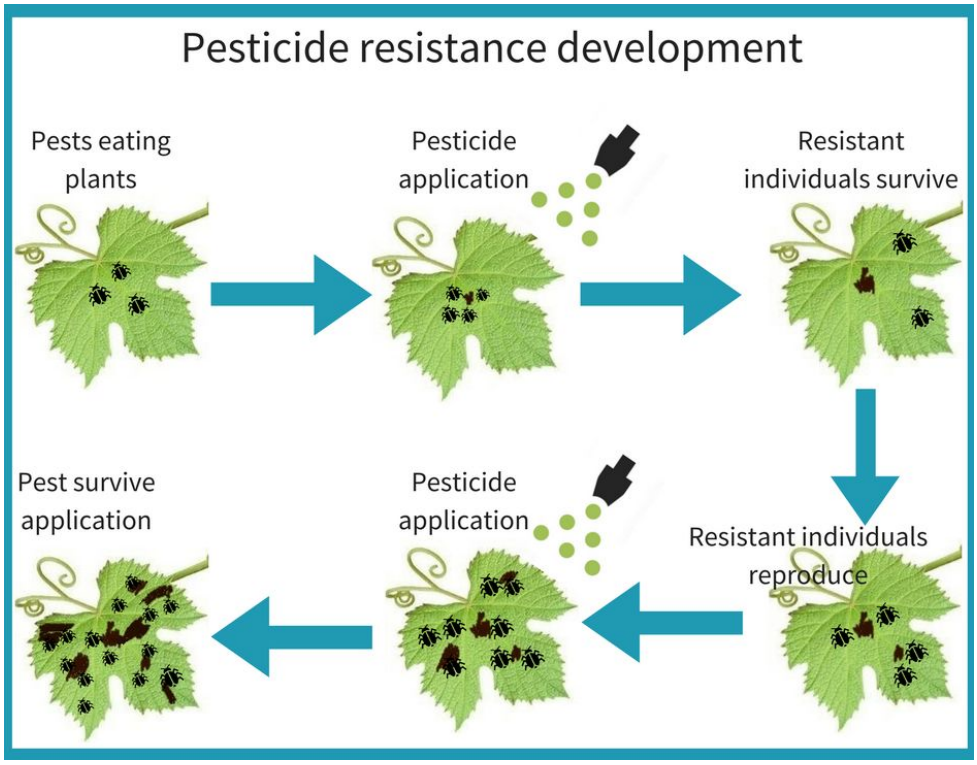
Insecticides can be divided into two major groups: **contact** and **systemic**. The contact insecticides do not enter in the plant, so they can protect only sprayed surface of the plant. While systemic insecticides enter into the plant and travel to other (not sprayed) parts of the plant. These insecticides 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.

Alternative for chemical pest control in the vineyard can also be ducks, which can help reduce the populations of slugs, grasshoppers and other pests in the vineyard.

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 the respiratory tract 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 is 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.



Sketch of pesticide resistance development of pests

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.

Application site	Foliar and ground
Mode of action	Contact and systemic
Spectrum of action	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 herbicides 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 damage 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 the 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. Therefore, a careful use of chemical pest control, like wearing protective clothes, timely spraying when non-harmful organisms are not inhabiting the vines, and taking into account the water zone regulations, is necessary.

Environmental hazard symbol

Acute toxicity hazard symbol

Application techniques

Method and quality of application have a big impact on the performance of the plant protection products. Through the appropriate application, winegrowers contribute to the reduction of pesticide consumption and pollution of the environment.

Plant protection products for the grapevine protection are usually applied by 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 environmental 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 the **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 into 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!

Application of PPP with tractor, photo by Emma Allen

Helicopter aerial pesticide spraying, photo Precision Helicopters Ltd.

"Hand" spraying of grapevines suitable for smaller vineyards, photo Cabbage Run Vineyards

When applying the pesticides, every winegrower should be aware that most of the pesticides leave residue on the crop, therefore it's necessary to consider several preventive measures 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 to 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.

Visible residues of the use of PPP on grapes, photo by S.Vranac

Conclusion

Since ancient times, 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**.

Currently widely recommended way due to its effectiveness 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, one-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 only chemical substances to protect their grapes.

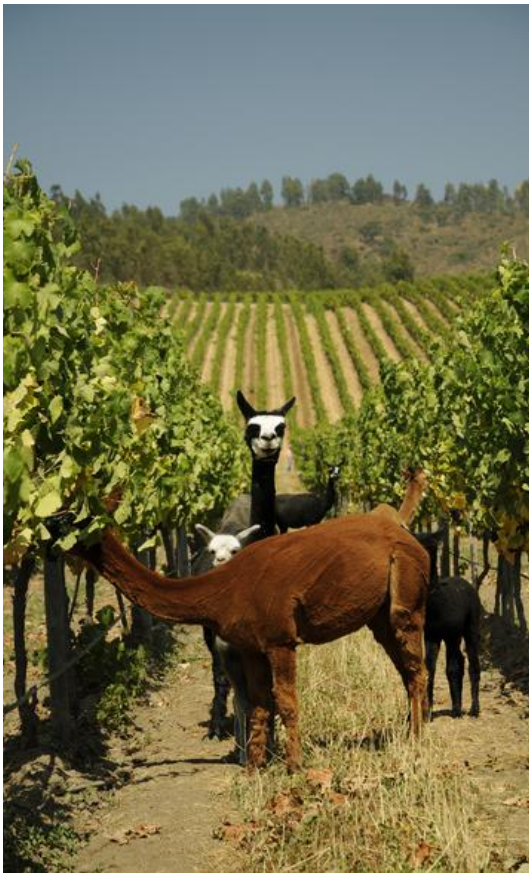
Ladybug on the grapevine leaf, photo Thelema Mountain Vineyards

Kangaroo in front of the vineyard, photo by Milton Wordley

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, systemic 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 to 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.



Lamas in the vineyard, photo Yampu tours

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