The Development of Grape Varieties: 
Towards a More Sustainable Viticulture

Characteristics of grape variety development -
Its history, present status and future

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1. Introduction

In par with a natural evolution of grape varieties, since the early days of viticulture new grape varieties have also been developed by man, to achieve:

- better wines (taste, aromas);
- a better cultivation (which may include: optimizing the moment of ripening (sugar content, aromas), yield, colour, ‘bunch architecture’, frost resistance);
- a more sustainable cultivation (disease resistance), especially since the mid-nineteenth century, when powdery mildew and downy mildew came over to Europe.

It is in the nature of man - and always will be - to strive for improvements. Moreover, the developments will also create new taste patterns, because the palate of consumers will evolve as well. This means that there is not one relevant palate, or taste pattern: there are several, evolving with the consumption of wine (region, is the wine savoured outdoors or at the dinner table, age of the consumer, etc.).

This continued development holds for both:

- \textbf{the classical varieties}, for example Pinot Noir or Pinot Blanc, where new clones may achieve a looser, and thus less botrytis-sensitive bunch (clone selection);
- \textbf{the new fungus-tolerant ('resistant') varieties}, with an initial focus on sustainability of cultivation, along with other possible characteristics of the cultivation - and of course a good wine quality. These varieties, by the way, will be called the "recent generations of new varieties" in this document.

Reducing the use of plant protection (mostly fungicides) is getting more and more attention in recent decades. We are looking more and more for varieties that have good fungus resistance, while at the same time yielding a good quality wine, without which such wines would of course be very poorly received.

The 2003 EU commission report 838 illustrates the importance of this fungus resistance for grapes, with the observation that even today “viticulture uses 40% of the crop protection products in the whole of agriculture”.

The present study wishes to address the relevant facts regarding the development of these varieties, by discussing their history, the current state of affairs – and future trends. Our aim is to bring together the relevant information in one report, to enable the reader to form a complete picture of this subject matter.

The information has been obtained by studying the literature listed in "Sources and references" below, and from studying data from various international databases (VIVC, UPOV, OIV), to which we refer in the section "Terminology". Also, attention is given to the activities of the main organizations working in this field, as listed under "Organizations".

One can observe that these developments towards grape resistance, together with good and better wine quality, are simultaneously taking place in several countries, with more and more mutual cooperation
between stakeholders. Most of these activities are supported as well by national governments and the EU, with the primary aim of creating a more sustainable viticulture.

The structure of this study is as follows:

- In Section 2, we start out by addressing what are – in fact – the major conclusions of our investigations, what can be learned from the information obtained;
- In Section 3, a (not too brief) summary of our findings is given;
- In Sections 4 through 6 the “Sources and references” used are given, as well as the "Terminology ", and the "Organizations" relevant to modern grape development;
- In the "Appendix", Section 8, further details will be presented regarding our subject, augmenting the summary of Section 3.

2. Conclusions: What can be learned from the information obtained

When one examines the facts, as we will in this study, the following can be concluded:

- The development of new grape varieties in terms of disease resistance, in combination with wine quality, is successful, and will continue, as it is socially desirable;
- The varieties developed can be used to make quality wines in accordance with EU regulations: PGI or PGI / PDO wines (depending on the classification used);
- With today’s recent new grape varieties, wine qualities can be achieved that are comparable to those of traditional, non-resistant grapes. There is e.g. no longer a ‘foxy’ flavor problem for recent varieties;

Of course, any good wine will continue to need clean, ripe grapes and good winemaking as its basis.

3. The development of grape varieties

3.1. The botanical system (which genus, with which subgenera, with which varieties)

In the botanical system, grapes belong to the Vitaceae family, which among others includes the genus Vitis, which in turn is divided into two subgenera:

- Vitis muscadinia (with chromosomes: 2n = 40, 20 pairs of chromosomes); Vitis rotundifolia is an example;
- Vitis euvitis (with chromosomes: 2n = 38, 19 pairs of chromosomes), which occurs on the different continents; the well known Vitis vinifera is an example.
It is within the subgenus *Euvitis* that new varieties are being developed. The varieties within the *Euvitis* group are ‘inter-fertile’, which means they can cross naturally.

Between *Muscadinia* and *Euvitis*, crossing is a more delicate matter, due to the difference in chromosomes. In 1972, Alain Bouquet (of INRA) started working on this problem. His crossing results (which will have both disease resistance, and *Vitis Vinifer* characteristics) are used by the various organizations that develop new varieties, such as INRA, WBI, JKI, etc., more on the subject can be found in the appendix.

### 3.2. The distribution of the subgenus *Vitis euvitis* across continents

The subgenus *Euvitis* has spread across several continents; continents that, since their separation from each other in ancient times, came to be even more fully divided by the Atlantic Ocean and the Gobi Desert. Because of this relative isolation, continents have known different evolutions.

- In North America, grapes have - through time - developed a natural resistance against phylloxera (the 'grape vine louse' that, in non-resistant varieties can easily destroy the roots of the grapes) and fungi. Grapes in North America have also adapted to the colder climate in winter (e.g. *Vitis Labrusca*).
- In Asia, there has also been an evolution towards disease resistance and further frost resistance (e.g. *Vitis Amurensis*).
- In Europe and the Middle East, no evolution towards resistance has taken place, because here, phylloxera or fungi were simply not present in the environment (*Vitis vinifera sativa / silvestris / caucasica*). The development of varieties here, is mainly a process induced by man.

**Natural evolution (especially in North America and Asia)**

A natural evolution from generation to generation will preserve the most favorable variations, allowing the favorable characteristics for the natural, local conditions to play an increasingly important role. As is schematically shown in this diagram:

![Mutation and Selection Diagram](http://commons.wikimedia.org/wiki/File:Mutation_and_selection_diagram)
A natural selection occurs in environmental conditions that can be divided into 'abiotic' and 'biotic'. Abiotic factors are the 'non-living' factors in the environment, such as temperature, humidity, nutrients in the soil and composition of the air. The biotic factors are (fellow) living beings that inhabit a particular environment. The complex of all living and non-living factors in a given area is called the ecosystem. Examples of ecosystems are a forest, or a desert. Because the conditions are different from forest to desert, organisms that can survive in a forest will have different properties from those that can survive in a desert. In this way, the environment determines who in the ecosystem will be the strongest, the most well-adapted and the fittest.

This also implies that when the environment changes, the organisms change with it, because other properties lead to a greater chance of survival and / or more offspring.

An important condition for the origin of species is isolation. Isolation ensures that groups with slightly different genetic material can no longer exchange their genes, with as a result that differences remain in existence, and will get even greater by natural selection.

In this way, to give an example, natural evolution has led to a type of vegetation along the (saline) sea front which ensures that the plants there are a lot more resistant to salt - or even need it - while plants that have developed alongside sweet water lakes will typically not like salt at all. Or take the well-known example of certain animals that exclusively live in caves - they are blind, because they have no need for eyes in the dark.

In this same manner, grape varieties have also known a natural evolution, where after fertilisation, very specific combinations of properties survived.

**Variety development by man (mainly in Europe)**

Next to a natural evolution, grape varieties have also been purposely developed by man. This work has been going on since the early days of viticulture, where one selects specific characteristics to get the desired better variety.

However, the specific properties obtained with fertilisations with the same combination of grape varieties can be very different from one fertilisation to another, which necessitates a selection of fertilization results. Fertilization will lead - in the meiosis - to chromosome pairs being mixed up, and even partially exchanged.

**Other variety changes**
3.3. Why one would want to develop new varieties

There were, and are, good reasons to develop new grape varieties through cross-fertilization. The most important are:

- to improve the quality of wines;
- to improve the cultivation, also in the light of the abiotic environmental factors such as time of harvest, number of hectoliters per HA, cluster architecture;
- frost resistance;
- to reduce susceptibility to disease (biotic resistance or tolerance), and thus the need for plant protection products, which involve risks for the vintner and his/her family, and lead to extra labor costs, related to spraying. Spraying will also affect the environment on a larger scale, e.g. by the accumulation of unwanted residues, poisoning the soil, and by compaction of the soil by motorized spraying activities.

Reducing the use of fungicides is also moving higher and higher up the agenda of the countries involved, including the EU, because of a growing commitment to sustainable agriculture for social reasons.

In the case of improving the wine quality or the cultivation of the same variety, we speak of the development of "clones". This process is similar to the development of resistant varieties, after the clonal selection (Essential Derived Variety, UPOV EDV) the planting, the winemaking, etc.

3.4. When is the development of a new variety succesful?

The development of a new grape variety may be called successful if quality wines can be made with the variety, that will find their way to the consumer, in addition to achieving other objectives, regarding properties of the cultivation, and/or sustainability. The combination of high wine quality, a sustainable viticulture and (possibly) cultivation improvements is crucial.

3.5. The history of the development of grape varieties

There are, and always have been, activities to develop new grape varieties, so that the quality of (a) wine may be improved, and/or a more effective cultivation becomes possible. Since the mid-nineteenth century, disease resistance also plays an important role.

From about 1840 on, the American 'grape vine root louse' phylloxera, together with two varieties of fungi, *peronospora* (or downy mildew) and *oidium* (or powdery mildew) came over to Europe, making it acutely necessary to devise means to ensure the survival of a then seriously endangered viticulture.
Those means - or measures - entail the following:

- the development of rootstock varieties (for example the so-called 5BB from Franz Kober, a riparia x berlandieri cross in 1895) from the living wood of American grape genotypes, which are resistant to root phylloxera. Today, grape varieties old and new will (almost always) be grafted on such rootstock varieties, to ensure root phylloxera resistance for the plant as a whole - as root phylloxera only endangers plant parts below ground;
- the development of grape varieties that have resistance characteristics with regard to powdery and / or downy mildew, inherited from an ancestor that already had a measure of natural fungus resistance. New grape varieties are used here as an alternative to an excessive use of copper and other organic chemicals in the vineyard. These alternatives for the use of fungicides get more and more attention as it is socially desirable - examples are the current Italian, German and French activities in this area.

The development of the recent generations of resistant varieties took place in several steps, in order to arrive at the desired varietal characteristics (resistance, cultivation, wine quality).

In the beginning the focus was on disease resistance, followed by further crossings with the main focus on wine quality and also cultivation characteristics. Certain favourable genotypes are selected, that is: plants with specific types of genetic information concerning e.g. resistance, cultivation and wine quality characteristics, in addition to maintaining and preferably improving fungus resistance. We are now in the eighth / ninth generation of this development.

An example is the development of the recent variety Bronner. The development goes back to 1828, followed by several further crossings of the previous crossing results, with as intermediate results varieties such as Seibel, Seyvve Villard and Merzling (up to nine crossing steps). Another example is Souvignier Gris, a variety of a recent generation, the result from crossing Cabernet Sauvignon and Bronner (see the pedigree diagram in Section 8, the Appendix).

The newly developed varieties are put up to receive variety protection, called “grower rights”. This will take some years to complete, including the verification of the characteristics of the variety with UPOV guidelines. This verification should conform the 'DUS' rules: Distinct, Uniform and Stable, genetically speaking. After that there will be an admission procedure (the addition to the national list of authorized grape varieties, and after that to the OIV list of varieties). The Netherlands, by the way, has no national catalog - the OIV list of varieties is being used.

3.6. EU Regulation 1308/2013. Integral CMO Regulation, which includes the basic regulation for wine, and Regulation No 607/2009 regarding its implementation

Since the year 2009, the EU regulations for wine contain the following provisions for the use of grape varieties.

Grape varieties can be used for winemaking when:
• the variety is on the national list of authorized grape varieties - or listed on the OIV list of grape varieties, for countries that have no national list of approved varieties (such as the Netherlands);
• the approved varieties are members of the species *Vitis vinifera*, or a cross of *Vitis vinifera* with a different species of *Vitis*.

Experimental cultivation may be possible, for the trial of new grape varieties that are not yet on the list of approved varieties.

In order to obtain a qualification as a PDO / PGI quality wine - *PDO* meaning "Protected Designation of Origin" and *PGI* "Protected Geographical Indication" *) - the following must be the case:

• only *Vitis vinifera* grapes may be used for wines with a Protected Designation of Origin (PDO);
• *Vitis vinifera* grapes and/or *Vitis vinifera* crossed with another variety of *Vitis* (also called ‘interspecific’) may be used for wines with a Protected Geographical Indication (PGI).

The above means that the current resistant varieties may be used for making quality wines of the 'PGI' variety, and those classified as Vitis Vinifera also for 'PDO' wines. For detailed information on the classification of the important current varieties we refer to Section 8, the Appendix.

*) Footnote: as a courtesy to our readers from the Netherlands, we would like to mention that the quality designation "PDO" translates in Dutch as "BOB" - "Beschermde Oorsprong Benaming", and "PGI" as "BGA" - "Beschermde Geografische Aanduiding".

### 3.7. Wine quality

A crucial factor in determining the success of a new, recent generation grape variety is the wine quality it may yield. Without a good quality wine there will be no proper acceptance of a grape variety - despite a possible good cultivation and good resistance properties.

Therefore, the determining question is: "What is the quality of the wines made from the current disease resistant varieties?".

Wine testings ("competitions") in several countries as well as specific tastings to compare wine quality, demonstrate that the wines of the recent new varieties are comparable in quality to reference wines such as Chardonnay and Pinot Noir, and that no special characteristics can be found - such as the notorious 'foxy' flavors known from the early days of resistant grape development. In Section 8, the Appendix, detailed information regarding wine quality is made available.
3.8. Future Developments

Expected future developments are:

- a further focus on sustainable viticulture. This focus is reflected in the projects of the organisations that initiate the further sustainability (such as ResDur), in France, but also in the EU-initiated project Innovine. From the Innovine website: “The strategic goal of the InnoVine project is to support the European wine industry by matching consumers' demands for top quality wines and food safety, citizen's requests for eco-friendly production methods and winegrowers technical needs in a climate change background”;
- the further development of new varieties, mostly from Udine (Italy), INRA (France), JKI / WBI (Germany), Pécs (Hungary) and Agroscope Changins (Switzerland). Preliminary results are expected around the year 2020. These future varieties will use multiple sources of resistance, such as Muscadina Rotundifolia / Kismish Vatkana (building up a resistance pyramid). These new developments often use the results of the work of Alain Bouquet (INRA). Results that will be used for further developments, as by JKI, WBI (continued crossings from 2003), Udine, Pécs and Agroscope Changins. There will also be further developments with regard to climate aspects such as drought;
- an acceleration of the development through the use of new tools that make the process of selection via molecular (DNA) markers more effective. It will, however still be a long process (15 to 20 years) to develop yet a new generation of varieties;
- the results of the developments described are obtained by natural fertilisation.

4. Sources and references

For the present study, the following sources were used.

- The article "Les cépages resistent aux maladies: panorama européen“, Jacques Rouseau et al., 2012.
- EU Regulation 1308/2013, Single CMO Regulation, which includes the basic wine regulation, as well as the regulation for its implementation No 607/2009.
- Report 2003/838. Report of the EU Commission, on the use of interspecific grape varieties, recently superseded by the EU wine regulations of 2009 - and the recent resistant grape varieties.
5. Terminology

Details of the main terms used in this study are as follows.

- **VIVC**, in full: "Vitis International Variety Catalogue". A list of grape varieties, which includes among other the mention of type and resistance characteristics.

- **From the VIVC website (www.vivc.de):**

  "The Vitis International Variety Catalogue (VIVC) is a database of various species and varieties / cultivars of grapevine, the genus Vitis.

  VIVC is administered by the Geilweilerhof Institute for Grape Breeding (Institut für Rebenzüchtung Geilweilerhof) in Siebeldingen, Germany, and contains information from grapevine collections existing in various institutes of viticulture around the world. As of April 2009, the information in the database brought together information from 130 institutions, located in 45 countries, and contains about 18,000 entries.

  The database was started in 1983, and has been available online since 1996. Its initial creation was supported by the International Organisation of Vine and Wine and the International Board for Plant Genetic Resources, a forerunner of Bioversity International. The purpose of the VIVC database is to provide documentation on available grapevine genetic resources, and to be a source of information to grape breeders, viticultural researchers and others.

  The information on grape cultivars in VIVC includes basic characteristics of the cultivars, holding institutes, passport data, and all known synonyms, which are quite numerous for many grape cultivars. In some cases, photos and genetic information (microsatellite information used for DNA profiling) are included.

- **UPOV** - in full: "The International Union for the Protection of New Varieties of Plants" in Geneva (French: "Union Internationale pour la protection des obtentions végétales"). UPOV gives racial guidelines for grapes, the characteristics of a variety, which are used in the verification of varieties.

  - **From the UPOV website (www.upov.int):**

    "The International Union for the Protection of New Varieties of Plants (UPOV) is an intergovernmental organization with headquarters in Geneva (Switzerland). UPOV was established by the International Convention for the Protection of New Varieties of Plants. The Convention was adopted in Paris in 1961, and was revised in 1972, 1978 and 1991.

    **UPOV ‘s mission is to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society.”**

    UPOV works with a list of about 50 phenotypic characteristics that are described, and which must show, on this level, the distinctive differences between the existing varieties and new varieties. The aforementioned ‘DUS’ is leading here: differences will become manifest by the ‘D’ of ‘Distinct’. This depends on the experts who actually compare varieties, or use their collective memory to indicate
the differences, so that each new variety may be distinguished from of existing varieties, together with a check whether the new variety falls within the Vitis vinifera group.

- **OIV**, in full: "Organisation Internationale de la Vigne et du Vin". Organization that is, among other things, responsible for the OIV list of varieties for member countries.

  **From the OIV website:**

  "The OIV is an intergovernmental organization of a scientific and technical nature of recognised competence for its works concerning wine, vines, wine-based beverages, table grapes, raisins and other vine-based products.
  One of the activities is the International list of grape varieties and their synonyms, the list of grape varieties of OIV member countries."

- **PDO**, in full: "Protected Designation of Origin" and **PGI**: "Protected Geographical Indication", as defined in the European Regulations european EU Regulation 1308/2013. Integral GMO regulation, which includes the basic wine regulation and Regulation No 607/2009 regarding its implementation.

- **Chromosome.** A chromosome [from the Greek χρώμα ('chroma') meaning 'colour' and σώμα ('soma') for 'body'] is a bearer of part of the genetic material (DNA) of an organism.

- **Recent generations of grape varieties.** Term is used in this study for the resistant grape varieties that have more or less recently become available (from about 2000 on).

- **Interspecific varieties.** Grape varieties that are the result of a cross of *Vitis vinifera* with a different kind of *Vitis*.

- **Wine quality.** The term used here for the quality of the wine.

- **Quality wine.** The term used here for PDO / PGI wines; for PDO and PGI see above.

- **Resistance pyramid.** The plant has several resistance genes and therefore several mechanisms of resistance.

### 6. Important Organizations for the development of new grape varieties

The most important organizations for the development of new, resistant grape varieties - and especially for the future - are the following.

- **INRA**, French National Institute for Agricultural Research in Colmar, the 'ResDur' project, and in Bordeaux and Montpellier. Since 2013, INRA also coordinates the European project 'Innovine' for sustainable viticulture.

- **IFV**, "Institut Francais de la Vigne et du Vin". French institute that coordinates the experiments with resistant varieties

- **WBI**, The German "Staatliches Weinbauinstitut" in Freiburg, also works with INRA.

- **JKI**, the German "Julius Kühn - Institut", also works with INRA, and works on the VIVC database.
- Istituto di genomica applicata (IGA) in Udine" (IT).
- Agroscope in Changins-Wädenswil (CH).
- Valentin Blattner - Volker Freytag (CH/DE).
- SZBI in Pecs (HU).

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- Jet Wester for her part in the English translation of the text.
8. Appendix. Detailed information on the development of grape varieties

8.1. Grapes in the botanical system

In the botanical system, grapes belong to the *Vitaceae* family, which includes the genus *Vitis* for grapes, which in turn is divided into two subgenera:

- *Muscadinia* (with chromosomes 2n = 40), with, as an example, *Vitis rotundifolia* in North America;
- *Euvitis* (with chromosomes 2n = 38), which occurs on various continents, where, after divisions by natural barriers (Atlantic ocean, Gobi desert), different natural evolutions have taken place.

  o In North America, a natural evolution has ensured a resistance to the there existing phylloxera and fungi, as in the *Vitis labrusca*.
  o In Europe and Asia Middle East, with *Vitis vinifera silvestris / caucasica / sativa*, phylloxera and fungi were traditionally non-existent, so there had been no need for a natural evolution towards resistance. So when phylloxera and fungi were imported from North America to Europe around 1840, the European grape varieties (being from the *sativa* family) were rather helpless in the face of these 'new' problems. There had been, however, significant other developments, induced by man, concerning the taste and cultivation of the grapes.
  o In Asia, a natural evolution occured, leading to a resistance and hardness against frost within e.g. the variety *Vitis amurensis*.

In natural evolution the selection, going from generation to generation, happens naturally. When varieties are developed by man, the determining factor is the specific selection by man, where the used selection criteria result in the next generation.

**Natural evolution (especially in North America and Asia)**

A natural evolution will preserve, from generation to generation, the most favorable variations, allowing the favorable characteristics for the natural, local conditions to play an increasingly important role. As schematically shown in the following diagram:
Natural selection occurs in environmental conditions that can be divided into 'abiotic' and 'biotic'. Abiotic factors are the 'non-living' factors in the environment, such as temperature, humidity, nutrients in the soil and composition of the air. The biotic factors are (fellow) living beings that inhabit a particular environment. The complex of all living and non-living factors in a given area is called the ecosystem.

Examples of ecosystems are a forest, or a desert. Because the conditions are different from forest to desert, organisms that can survive in a forest will have different properties from those that can survive in a desert. In this way, the environment determines who in the ecosystem will be the strongest, the most well-adapted and the fittest.

This also implies that when the environment changes, the organisms change with it, because other properties lead to a greater chance of survival and / or more offspring.

An important condition for the origin of species is isolation. Isolation ensures that groups with slightly different genetic material can no longer exchange their genes, with as a result that differences remain in existence, and will get even greater by natural selection.

In this way, to give an example, natural evolution has led to a type of vegetation along the (saline) sea front which ensures that the plants there are a lot more resistant to salt - or even need it - while plants that have developed alongside sweet water lakes will typically not like salt at all. Or take the well-known example of certain animals that exclusively live in caves - they are blind, because they have no need for eyes in the dark.

In this same manner, grape varieties have also known a natural evolution, where after fertilisation, very specific combinations of properties survived.
Variety development by man (mainly in Europe)

Next to a natural evolution, grape varieties have also been purposely developed by man. This work has been going on since the early days of viticulture, where one selects specific characteristics to obtain the desired, better variety.

However, the specific properties obtained with fertilizations with the same combination of grape varieties can be very different from one fertilization to another, which necessitates a selection of fertilization results. Fertilization will lead - in the meiosis - to chromosome pairs being mixed up, and even partially exchanged.

Other variety changes

Mutations are small changes in DNA. For example, UV light can alter DNA bases by which characteristics may change. Or another example: human beings accumulate about twenty DNA-changes in their life, that can be transferred to their offspring.

As may already be inferred from the above, it is indeed possible for a grape variety to change relatively easily - even in the vineyard.

8.2. Varietal characteristics

UPOV, in Geneva, (French: Union internationale pour la protection des obtentions végétales) defines the international guidelines regarding the characteristics of grape varieties, which are then used for the verification / identification of the variety. These characteristics must comply with the so called 'DUS'-rules (they must be genetically Distinct, Uniform and Stable) during the procedure by which growers obtain breeding rights, by an independent organization for the protection of grape varieties. The aim is a classification of the race, as e.g. Vitis vinifera or 'inter-specific'.

Here, the following should be noted. There are many characteristics that do not lead to varietal differences. A good example is skin color for members of the - one and the same - human spieces; the same holds for e.g. red wine grapes, with the red dye malvidin diglucoside and the different types of anthocyanins (acetyl, cumaryl).

The UPOV-defined groups of authentication are as follows for grapes (From the UPOV Vitis "The guidelines for the conduct of tests for Distinctness, Uniformity and Stability").

"5. Grouping of Varieties and Organization of the Growing Trial

5.1 The selection of varieties of common knowledge to be grown in the trial with the candidate varieties and the way in which these varieties are divided into groups to facilitate the assessment of distinctness are aided by the use of grouping characteristics.

5.2 Grouping characteristics are those in which the documented states of expression, even where
produced at different locations, can be used, either individually or in combination with other such characteristics: (a) to select varieties of common knowledge that can be excluded from the growing trial used for examination of the development of distinctness; and (b) to organize the growing trial so that similar varieties are grouped together.

5.3 The Following have been agreed as useful grouping characteristics:

(a) Young shoot: openness of tip (characteristic 2)
(b) Young leaf: color of upper side of blade (characteristic 6)
(c) Young leaf: prostrate hairs between main veins on lower side of blade (characteristic 7)
(d) Flower: sexual organs (characteristic 16)
(e) Mature leaf: number of lobes (characteristic 20)
(f) Time of beginning of berry ripening (characteristic 31)
(g) Berry: shape (characteristic 36)
(h) Berry: color of skin (without bloom) (characteristic 37)
(i) Berry: anthocyanin coloration of flesh (characteristic 40)
(j) Berry: particular flavor (characteristic 42)
(k) Berry: formation of seeds (characteristic 43) 

8.3. Development of varieties

Grape varieties are being developed to obtain better characteristics:

- in terms of taste and aroma of the wines they yield;
- also to achieve a better cultivation with regard to harvesting time, frost susceptibility, cluster architecture, upright flowering and harvest volume;
- since the mid-nineteenth century, disease resistance also came into play in the desire and/or need to achieve better results.

In all cases, the results should give a good quality wine.

Developments within existing varieties, i.e. clonal selection, resulting in an 'EDV', for 'essential derived variety', are called clones. For example: new Pinot Noir clones, to obtain better bunch architecture. The steps in the development of such clones are equivalent to those leading to the development of disease resistant varieties.

Important activities are being developed to obtain more disease-tolerant grape varieties, so that the amounts of fungicides in the vineyard may be reduced - as is done in France, Germany, etc. The important prerequisite here remains of course a good wine quality. These activities are becoming more
and more socially desirable and will be supported by the societies of several European countries, and the EU.

To develop new grape varieties, one can distinguish two basic methods:

- Crossing of genotypes of the same species, for example of *Vitis Euvitis*, which are inter-fertile and can be crossed in a natural way;
- Crossing of different subgenera of *Vitis*, such as *Muscadinia with Euvitis*. Such crossings are more delicate, because of the differences in chromosomes between the subgenera. Alain Bouquet (INRA) has been working on this problem since 1972, which resulted in a cross of *Muscadinia rotundifolia* with *Vitis vinifera*. This result had important new resistance characteristics, and after further crossings a result was obtained which has these resistance traits, together with all *Vitis vinifera* characteristics.

A more recent collaboration between WBI Freiburg, JKI Geilweilerhof, Pecs, Udine, Agroscope Changins and the French INRA, continues to work in this promising direction. The basis of Alain Bouquet’s work is used to arrive at a form of resistance which is permanent, not reduced by the evolution of fungi. Results are expected from the year 2020.

How does one choose a selection, to determine what to cross:

- An empirical selection, the result of a process of several years, to obtain a better level of resistance, taste, cultivation characteristics, etc. This is the method that has been used until now;
- A more recently developed method uses for the selection (what to cross) specific characteristics (molecular markers) that are found, and that can help to achieve good selections in a slightly shorter time. Nonetheless, it will still take between 15 and 20 years to obtain a good new variety.

Crossing is not a short-term process.

One uses a crossing result for further crossings, to obtain further improvements from generation to generation with regards to e.g. flavour and / or cultivation, while maintaining the fungus resistance that was reached.

At first, the focus was on resistance, followed by further crossings with a focus on wine quality and cultivation characteristics. One selects again and again the desired genotypes, that is to say: specific combinations of genetic information concerning among other things disease resistance, cultivation and wine quality, to reach the desired characteristics or properties of the grapes.

We are now in the eighth or nineth generation of this development. Since the past 185 years, this has led to the current level of quality of the recent generation of new varieties. As an example of the long-term character of this line of work: crossings of potatoes, the process of which has lasted for 50 years, with many crossings and selections, in order to finally obtain a good resistance against potato diseases (while maintaining quality).

After a crossing, from the many resulting plants those are chosen that have the best properties (genotypes) to continue to work with.
The following figures illustrate the scale of the process to obtain recent new grape varieties (adapted from "60 Jahre Resistenzzuchtung am WBI, 1950 to 2012, Dr. Volker Joerger")

- approximately 1500 crossings (combinations);
- approximately 39,000 fertilizations;
- approximately 750,000 seedlings were raised and infected with diseases;
- approximately 46,000 seedlings with enough disease resistance were tried in a vineyard environment;
- about 6,300 wines were made of these, and tasted for quality;
- the result of all this is: 15 varieties are being tested further, and 10 varieties have been admitted in one or more countries.

An example is the grape variety "Bronner", which is the result of about nine steps, the first one as early as 1828, with intermediate results such as varieties Seibel, Seyvve Villard and Merzling.

See the 'Bronner pedigree' of WBI Freiburg:
The next step was the crossing of Bronner with Cabernet Sauvignon, resulting in the very recent variety Souvignier Gris.

From WBI information: "Souvignier Gris ist eine neu (1983) gezüchtete pilzwiderstandsfähige weisse Kelter-Rebsorte. Souvignier Gris wurde am Staatlichen Weinbauinstitut Freiburg durch Norbert Becker aus den Sorten Cabernet Sauvignon (as Muttersorte, ♀) und Bronner (as Vatersorte, ♂) gekreuzt".

8.4. The history of the development of grape varieties

New grape varieties have been developed for centuries, to obtain better taste and / or cultivation parameters. Concerning the development of disease resistance, one can see the following:
**Sixteenth to nineteenth century**

Crosses in America to prevent problems such as susceptibility to frost and disease in imported *Vitis vinifera*.

**From about 1840**

After the arrival of mildew in Europe, solutions were sought through crop protection (chemicals) and the use of American varieties. However, this import meant that more phylloxera and more downy and powdery mildew were brought in, destroying the European vineyards from 1840 on.

This has led to the grafting of grapes onto developed rootstock varieties (for example the so-called 5BB from Franz Kober, a riparia x berlandieri cross in 1895), from the living wood of American grape genotypes, which are resistant to root phylloxera. With this grafting, the actual 'noble' race (for the making of the wine) will retain all its specific varietal characteristics. Nowadays, these rootstocks are used worldwide, and are optimized for the place where they are planted (drought, sand, etc.).

In addition, especially in France, from 1875 to 1940 grape varieties were developed that have a certain disease resistance, such as Marechal Foch, Seyval, Chambourcin. This led to the planting of about 400,000 hectares in 1958. A ban (in 1927) to use these varieties for AOC (quality) wines reduced the use of them drastically, and also reduced the development of further resistant varieties. Twenty varieties are today on the list of permitted varieties, e.g. Chambourcin, Seyval, Leon Millot, Marechal Foch (inter-specific varieties).

**1940 to 2000**

So in France, growers were no longer interested in resistant varieties, due to the AOC regulations. However, since 1972, Alain Bouquet (INRA) worked on further potential varieties, with as a result a crossing of *Muscadinia rotundifolia* with *Vitis vinifera*. This result had the desired resistant characteristics, and after further crossings a result was obtained that had these same resistant traits, together with all characteristics of *Vitis vinifera*.

In Germany, in different institutes, such as WBI in Freiburg (from 1922/1930, based on the earlier French crossings), LWG (since 1936) and JKI, varieties have been, and are being developed, in which above all, generation after generation, the wine quality and cultivation are main points of attention.

Examples of the recent generations of new varieties are:

- **White (or Gris):** from Merzling, Johanitter, Helios, Solaris and Bronner to Muscaris, Souvignier Gris;
- **Red:** from Regent to Cabernet Cortis, Cabernet Cantor, Prior and Monarch.

Parallel to these are the developments by Valentin Blattner (CH) / Volker Freytag (DE), with their recent generation of new varieties such as:
- Cabernet Blanc, Cabernet Noir, Cabertin, Cal 6-04, Pinotin.

In Eastern Europe, there have been several developments, with actual uses in the vineyards there - but these have been reduced since the end of the communistic era, due to loss of financial funding.

**Twenty-first Century**

- The use of new sources of resistance characteristics, to enhance the durability of the resistance (specifically selected from *Muscadinia rotundifolia* and possibly *Kismish vatkanai*); this includes working with multiple mechanisms of resistance.
- The use of new tools achieve selections with specific characteristics (marqueurs / markers), which can help to develop the best new crossings, with some acceleration of the crossing process as a bonus. However it still takes 15 to 20 years to develop a good new variety.

**8.5. What can be expected in the next decades**

- A further focus towards a more sustainable viticulture, while preserving wine quality.
- New varieties from mainly Udine (IT), INRA (FR), JKI / WBI (DE) and Agroscope Changins (CH). The first results are expected around 2020. These projects use multiple sources of resistance, as from *Muscadinia rotundifolia* / *Kismish vatkanai* (resistance pyramid, the plant has several resistance genes and therefore multiple resistance mechanisms). This development is based on the work of Alain Bouquet (INRA), which is used for further work with various organizations, such as by JKI, WBI (continued crossings from 2003), Udine, Pecs and Agroscope Changins. The first grape varieties of this generation are expected from 2020.
- Accelerating the development of varieties through the use of new tools in the process of selection (molecular markers). This can speed up developments, but will still take 15 to 20 years.

**8.6. Status of development of varieties**

Firstly, it must be noted that the interest in new grape varieties which lead to a good wine quality, while being at the same time very disease resistant, is considerable. An example is France, where recently a program has been started to augment the list of approved varieties with varieties of the newest generation of resistant varieties (coordinated by IFV, *Institut de la Vigne et du Vin*, with a.o. INRA). This development can also be seen in Italy.

An important element here is the social desirability to achieve a more sustainable viticulture. The EU project Innovin is also a case in point.

A more sustainable viticulture means:
- reducing the use of crop protection products, including copper, with the related reduction of pressure on the environment, risk to the vintner, etc.;
- lower production costs per hectoliter (less crop protection products, less labor);
- fewer passes through the rows, resulting in a reduction of the compaction of the corridors between the grapes, and the corresponding loosening of the soil.

8.6.1. What these developments have brought us

New resistant varieties are being developed in steps (generations), where every next step means a further development of the previous result in terms of resistance, but also in terms of the wine quality and/or characteristics of grape cultivation. We now see varieties of the eighth and ninth generation of crossings.


After crossing, these new varieties are subjected to several years of further selection and tests, before they come on the market, first of all for what is called 'trial cultivation'.

These varieties go through a very meticulous process to obtain a protection of the variety ('breeder's right'), which takes several years, and which also includes the authentication / identification of the variety (using the UPOV guidelines - French: Union internationale pour Protection des obtentions végétales). After that there is the national authorization procedure (addition to the national list of approved varieties), which also takes several years (verifications through a pilot cultivation).

In the Netherlands by the way, a variety is permitted if it is on the OIV list of varieties, which simply means that the variety was already accepted in another country.

Below are the results for the most important members of the recent generation of new varieties, taken from the VIVC varietal information and the OIV varieties list (VIVIC is short for the Vitis International Variety Catalogue).

**VIVC-classified as Vitis vinifera; and are on the OIV list:**

- Baron (n);
- Bronner (b);
- Cabernet Blanc (b);
- Cabernet Cortis (n);
- Cabernet Jura (n);
- Cabertin (n);
- Helios (b);
- Johanniter (b);
- Merzling (b);
- Monarch (n);
- Muscaris (b);
- Pinotin (n);
- Prior (n);
- Regent (n);
- Solaris (b);
- Souvignier Gris (g).

**VIVC-classified as inter-specific; and are on the OIV list:**

- Muscat Bleu (n).

**Classification for the following variety is in process** - are waiting for completion of the procedure of the protection of varieties, prior to a VIVC update of the data:

- Cabernet Cantor (n);
- Cabernet Noir (n);
- Cal 6-04 (b).

These varieties have proven that it is possible to minimize the use of crop protection products, e.g. from every two weeks (traditional situation) to only 0 to 3 times per season; the lowest rate holds for the latest generation of new varieties.

**Vineyards with these varieties**

A re-planting of an existing vineyard with new grape varieties is not something that is done lightly, or quickly, as it will mean a loss of yields, for at least a few years to come. This means that the new, more resistant varieties are usually planted in new vineyards first, as was possible in the Netherlands (with no 'traditional' vineyards to speak of), with the additional advantage that the bunches of most of these varieties ripen relatively early - a very welcome addition given the moderate sea climate of the Netherlands.

Planting has mainly taken place in the more northern part of Europe (as in the Netherlands, Belgium, Germany, Austria, Switzerland, Denmark, Sweden, Southern Tyrol, North of Italy (in Veneto, Trentino, Piemont etc.). In all, the new varieties have been planted in about 30 countries.

In France people and organizations are actively working on the construction of pilot vineyards (project *VATE Marsillarques and Domaine de Cazes*), to gain experience, and to work on the addition of these new varieties to the list of permitted varieties in France.
8.6.2. EU Regulation 1308/2013 Integral CMO Regulation, which includes the basic wine regulation, and Implementation Regulation No. 607/2009

Since 2009, the EU regulations for wine contain the following provisions for the use of grape varieties:

- Varieties can be used for wine making when listed on the national list of authorized varieties, or when listed in the OIV catalog, for countries without their own list of approved varieties.
- Approved varieties are of the genus *Vitis vinifera* or a cross of *Vitis vinifera* with a different kind of *Vitis*.

When a variety is not yet on the list of approved varieties, it may possibly be used for (experimental) trial plantings.

Varieties for PDO / PGI quality wines:

- The designation 'Protected Designation of Origin' (PDO) is reserved for wines made from grapes classified as *Vitis vinifera*.
- The designation 'Protected Geographical Indication' (PGI): may be used for wines made from grapes classified as *Vitis vinifera* or *Vitis Vinifera* crossed with another variety of *Vitis*.

This means that the developed disease tolerant varieties can be used for making quality wines: they may be used for PGI wines, and those classified as *Vitis vinifera* may also be called PDO wines - see the classifications of these varieties in Section 8.6.1.

8.6.3. The quality of wines made from the latest generation of new varieties

Making good wine from grapes of the standard (non-resistant) varieties, or from the latest generation of new varieties (resistant varieties) will depend in both cases on the quality of the crop (such as the ripeness of the grapes at harvest) and the wine making.

The wine quality of the latest generation of new varieties is being measured at several wine testings, with results such as the following.
In international competitions, such as the Berliner Wine Trophy, AWC Vienna (in 2013 12,299 wines) or Mundis Vini (6000 wines), multiple medals are being given to wines from the recent generation of new grape varieties, 'shoulder to shoulder', so to speak, to wines made from standard, traditional varieties. Examples are:

<table>
<thead>
<tr>
<th>Competition</th>
<th>Variety</th>
<th>Gold</th>
<th>Silver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vienna AWC 2013</td>
<td>Bronner</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Pinotin</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Regent</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Johanniter</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Muscaris</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Solaris</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Cabernet Blanc</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Cabernet Cortis</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Souvignier Gris</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Mundis Vini 2013</td>
<td>Regent</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Muscaris</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pinotin</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Johanniter</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Solaris</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

In the Netherlands, the yearly national wine competition event shows that every year, the wines from the recent generation of new varieties get better reviews from the professional panel of judges. In 2013, 73% of the 157 wines were given 75 points or more (OIV scale), while 32 wines of the recent generation of new varieties earned a medal. This percentage has gone up from year to year. By comparison: in 2012 it was 62%.

The 2013 medals for each new variety are as follows (mono-cépage or main variety in a cuvée):
### German experimental results

German experimental results have shown that the latest generation of new varieties can yield wines with a quality corresponding to those of standard varieties such as Pinot Noir and Cabernet Sauvignon. There are e.g. the 2003 comparisons with Cabernet Sauvignon and Spätburgunder (German Pinot Noir) where an equivalent wine quality is indicated.

Another example is the ECOVIN Baden Prämierung 2014, with good results for biologically grown and made Johanniter, Cabernet Cortis, Muscaris, Regent and Cabernet Blanc.

In France, the wine quality of 57 wines from 32 new varieties was compared to standard (reference) varieties like Chardonnay, Merlot and Pinot Noir. This was done in 12 tastings with a total of 190 tasters. The result was that one can rightly speak of a similar wine quality for the new and the reference varieties; see the book *Les Cepages Resistants*, with details for each variety.

The tastings were organized by the ICV (Institut Coopératif du Vin).

<table>
<thead>
<tr>
<th>Competition</th>
<th>Variety</th>
<th>Gold</th>
<th>Silver</th>
<th>Bronze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wijnkeuring der Lage Landen 2013</td>
<td>Johanniter</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Souvignier Gris</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pinotin</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cabernet Cortis</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Merzling</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Monarch</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cabernet Blanc</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cabertin</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Muscat Bleu</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regent</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Solaris</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Rondo</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>Riesel</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seyval Blanc</td>
<td>1</td>
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</tr>
</tbody>
</table>
The tastings were also meant to verify a possible 'foxy' nature of the wines, with the following result for the latest generation of new varieties, including the values of the standard (reference) wines:

- **For white wines, a comparison is made with Chardonnay, and one can see small differences upwards (more) and down (less)**

  The 'foxy'scale for the recent generation of new varieties shows for the Foxy flavor (scale from 1 to 5): "very low" when from 1 to 1.5, "low" when from 1.5 to 2, and "high" for 5:

  - Sauvignon Soyihières (very low) and more than Chardonnay
  - Souvignier Gris (very low) and equal to Chardonnay
  - Solaris (very low) and as good as similar to Chardonnay
  - Muscaris (very low), and equal to Chardonnay
  - Merzling (very low), and equal to Chardonnay
  - Johanniter (very low) and as good as similar to Chardonnay
  - Cabernet Blanc (very low) and as good as similar to Chardonnay
  - Bronner (very low), and equal to Chardonnay

- **For rosé wines, with a comparison to Pinot Noir Rose, the result is:**

  - Regent (very low) and less than Pinot Noir
  - Cabernet Cortis (low) and less than Pinot Noir
  - Muscat Bleu (low) and less than Pinot Noir

- **For red wines, the results are:**

  - Cabernet Cortis (low)
  - Cabertin (very low)
  - Monarch (between 2 and 2.5)
  - Pinotin (very low)
  - Regent (low)
  - Prior (low)

Example from the IVC edition "Les cepages resistants" of the information found per variety: here Souvignier Gris (see next 2 pages)
Cépage blanc

Souvignier gris®
synonyme : Fr 392-83

Origine
Parents : Cabernet-Sauvignon x Bronner®
Année d'obtention : 1983
Obtenteur : Staatliches Weinbaunstitut Freiburg (Alsace)
Hybrideur : Dr. Norbert Becker

Phénologie
Époque de débourrement : moyen, similaire au Pinot blanc
Époque de maturité : moyen à tardif, 1 semaine après le Pinot blanc
Phénologie observée dans les régions suivantes : Allemagne (Pays de Bade), Suisse (Zürich), Azeeche (Styrie)

Aptitudes agronomiques
Rendement : 6 à 20 t/ha
Vigueur : forte
Stratégie phytosanitaire : 0 à 2 traitements recommandés

Degré de résistance aux maladies
- Mildiou
  - Sur 10 sources d'informations
  - Sur 9 sources d'informations
- Botrytis
  - Sur 10 sources d'informations
  - Sur 7 sources d'informations
- Oïdium
  - Sur 10 sources d'informations
  - Sur 6 sources d'informations

Commentaire
Risque de coulure et de dessèchement de la rafle très faible, port érigé. En expérimentation depuis 2012 dans l'Hérault et l'Aude (Chambres d'agriculture, CEHM Marsillargues et Domaine de Cazes).
Potentialités technologiques

Dégustation : 1 vin italien issu de l'agriculture biologique, millésime 2010

Analyse :
- pH: 3.3
- acidité totale: 4.2 g H₂SO₄/l
- test détection d'hybride: non concerné
- tanins (DO 280): 6.4

Intensité colorante
Verdâtre - jaune - brun

Sourcé
Foxé
Boisé
Amylétique
Herbacé
Jimmy
Fruits exotiques
Fruits blancs au sirop
Fruits confits
Aframis
Volume
Acidité
Rugosité
Astringence
Sécheresse
Amertume

Profil sensoriel ASDQ établi par le panel ICV

Classement
Sauvignon gris - 3ème/17
(Chardonnay: 3ème)

Évaluation par le panel professionnel (26 dégustateurs)