The resistant *gene*ration

State of the art 2022: creation of the new VCR varieties

The speed with which the market evolves is rarely compatible with the development of a new technology in viticulture; the “normative” limitations also irretrievably expand the time needed to adopt new viticultural models, sometimes trivializing or even making inefficient the research efforts. Despite these difficulties, the Vivai Cooperativi Rauscedo (VCR), in the belief that Research and Experimentation are the only weapons to face the challenges of the future, have launched a far-sighted genetic improvement program based on the techniques of cross-breeding and selection, involving more than 70 varieties of wine and table grapes, which well represent the national and international ampelographic panorama.

Wine grapes

In 2006, the Vivai Cooperativi Rauscedo had perceived the need to give concrete answers to the emerging challenges in terms of nursery-viticultural sustainability. For this reason, they started a fruitful collaboration with the University of Udine and the Institute of Applied Genomics with the aim of providing vine-growers with new wine grape varieties resistant to downy mildew and powdery mildew. The first ten resistant varieties, which VCR is the exclusive licensee of, were registered in the National Catalogue in 2015.

After reaching this first milestone, the evaluation was focused on new varieties, also created by the University of Udine from the crossing of Pinot Noir and Pinot Blanc with new and more performing resistance donors. In 2020, four new vines resistant to downy mildew and powdery mildew were registered in the National Register of Vine Varieties: Pinot Iskra b., Kersus b., Pinot Kors n. and Volturnis n. In 2021, the varieties were authorized for cultivation in Friuli Venezia Giulia and Veneto regions.

Since 2015, VCR has started their own crossbreeding program with the aim of obtaining new resistant wine, table and rootstock varieties. The project includes the most representative national and international varieties that, with the introgression of genes for resistance to diseases and abiotic stresses, could make the viticulture of our planet 360 ° sustainable, promoting its adaptation to the current climate change.

Particular attention has been paid to autochthonous varieties and their clones, which represent the strength of Italian viticulture. Basically, for VCR, these new varieties are "Improved Autochthonous

Varieties" as they were selected with the aim of combining tradition and innovation in their DNA. These varieties are distinguished by:

- an aromatic and polyphenolic profile of quality and typicality comparable, if not superior, to that of the parent of *V. vinifera*;
- good agronomic and oenological profile and high polygenic resistance to fungal diseases and abiotic stresses;
- a resistance to diseases that guarantees a tangible reduction in phytosanitary treatments and related costs;
- allowing the creation of vineyards with high environmental sustainability;
- satisfying the needs of consumers in terms of high quality and healthiness of the relative wine.

Figure 1. Pollination of emasculated flowers

In recent years, hundreds of different crosses have been made, resulting in hundreds of thousands of resistant genotypes, which are undergoing agronomic and oenological evaluation. In the near future, resistant varieties deriving from Glera, Nebbiolo, Sangiovese, Cannonau, Trebbiano Romagnolo and Toscano, Malvasia Istriana, Carignano, Traminer, as well as other varieties deriving

from important French (Semillon, Chenin blanc, Tannat, Syrah etc. .), Spanish (Albarino, Parellada, Macabeo, Godello etc.) and Eastern Europe (Riesling Bianco and Italico etc.) varieties will therefore be available on the market. At the end of the improvement process, lasting about 15 years (from seed to genotype ready for registration in the national catalogue), 2-3 genotypes of each variety subjected to crossing will be available. For some of these varieties, Glera in the first place, the breeding program is completed, and the best performing genotypes have been submitted for registration in the National Register of Vine Varieties in 2022.

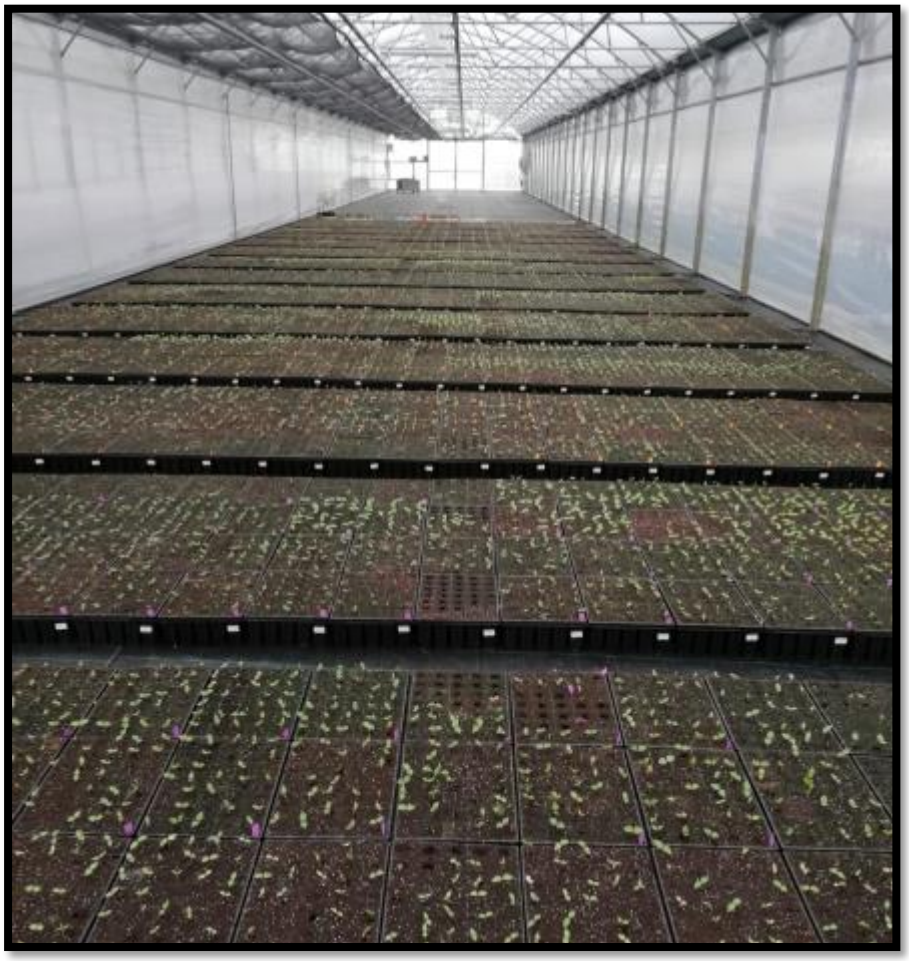

Figure 2. Germination of seedlings in greenhouse

The new genotypes are subjected to careful sanitary selection for secondary diseases, preferring those less susceptible to black rot and/or dead arm. The agronomic aspect also played a significant role in the choice of individuals: the morphology of the bunch (preferably loose and medium, medium-large size) and the good productivity per vine represented the discriminating characteristics during field inspections. Finally, the microvinifications and the organoleptic

evaluation carried out by commissions of oenologists have made it possible to identify genotypes with comparable or improved aromatic and phenolic profile compared to the noble parent.

The varieties have excellent polygenic resistance to the aforementioned diseases, good productivity and vigor, and an oenological potential comparable or superior to the *V. vinifera* parents. The most advanced selections (such as, for example, the crosses with Glera and Traminer) are currently in the fourth year of agronomic and oenological tests at an experimental plot located in Rauscedo, while other experimental fields, more recently, have been established in different Italian regions. These new crosses, at the first tastings, were particularly appreciated by winemakers, oenologists and consumers in general.

Since 2010, numerous crosses were made between Glera and various resistance donors. Through a very scrupulous selection, two resistant varieties were identified and presented to Italian Minister of Agriculture under the name of Glyres and Resilia. Thanks to the presence of six resistance genes (*Rpv 3, Rpv 12, Rpv 1, Run 1, Ren 3* and *Ren 9*), the varieties have excellent resistance to downy mildew and powdery mildew, good tolerance to black rot and dead arm. They have good vigor with an erect or semi-erect growth habit.

Glyres (code VCR-15-1-1-52) is a white grape variety obtained from the cross with Glera; it has a medium-large, wedge-shaped leaf with 5 lobes and a U-shaped petiole sinus and a large, funnel-shaped, compact cluster with three-four wings. The berry is medium-to-small of spheroidal shape. Golden-green coloured rather thick skin with medium pruinosity. Soft pulp with neutral flavour. The bud break-flowering-veraison-ripening periods and the high yields are comparable with the noble parental Glera. On a sensorial level Glyres wine is very similar to the parental variety Glera. The aromatic profile shows a good intensity of tropical, floral, and citrus aroma with prevalent notes of rose and lavender thanks to the higher concentrations of terpene compounds. The wine has remarkable freshness and persistence. It is suitable to produce high-quality sparkling wines or perfumed wines with short aging.

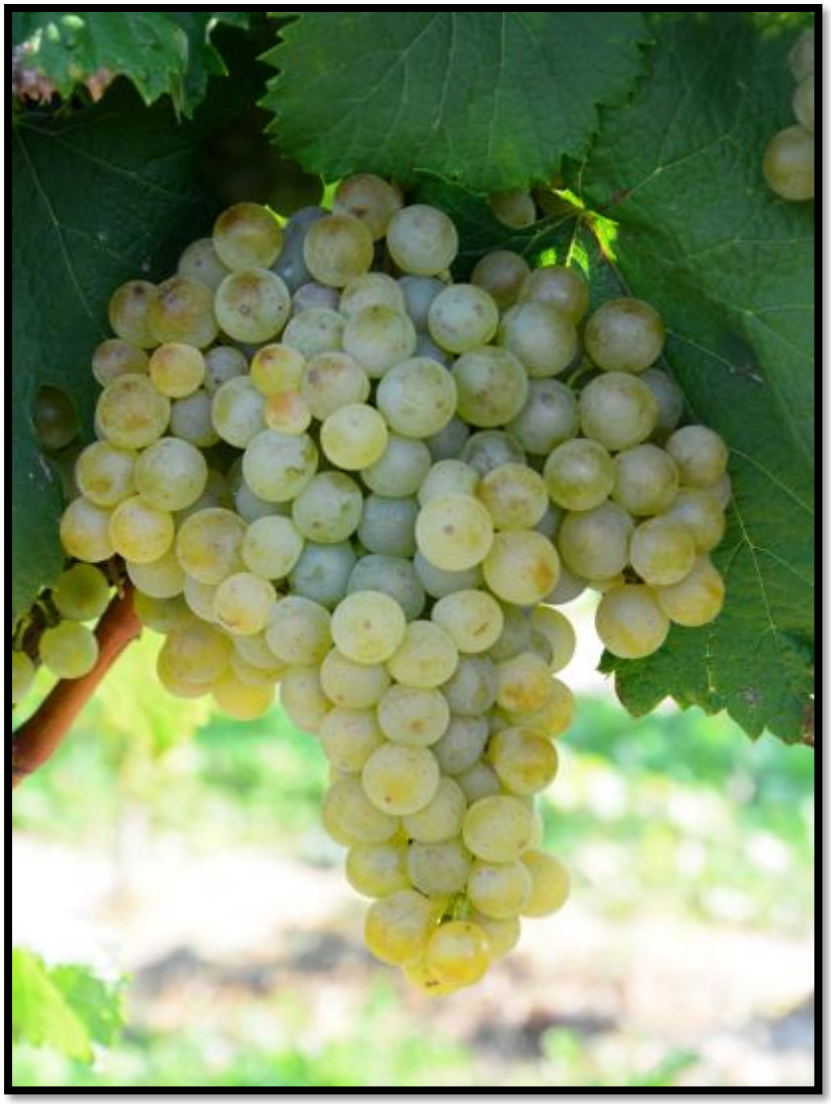

Figure 3. Bunch of Glyres

Resilia (code VCR-15-1-1-180) is a white grape variety, obtained from the cross with Glera. The leaf is medium-large, pentagonal with 5 lobes and V-shaped base petiolar sinus. Large conical clusters, tendentially compact with two or three wings. The berry is medium of broad ellipsoid shape. Golden-green coloured rather thick skin with medium-to-low pruinosity. Soft pulp with neutral flavour. The bud break-flowering-veraison periods are later than in the case of the noble parent Glera. The maturation is about 7 days later than the Glera. On a sensorial level Resilia wine is very similar to the parental variety Glera. The aromatic profile shows a good intensity of tropical and floral aromas, in particular notes of rose and violet. The wine has remarkable freshness, persistence, and structure. It is suitable for the production of high-quality sparkling wines or perfumed wines with short periods of refining.

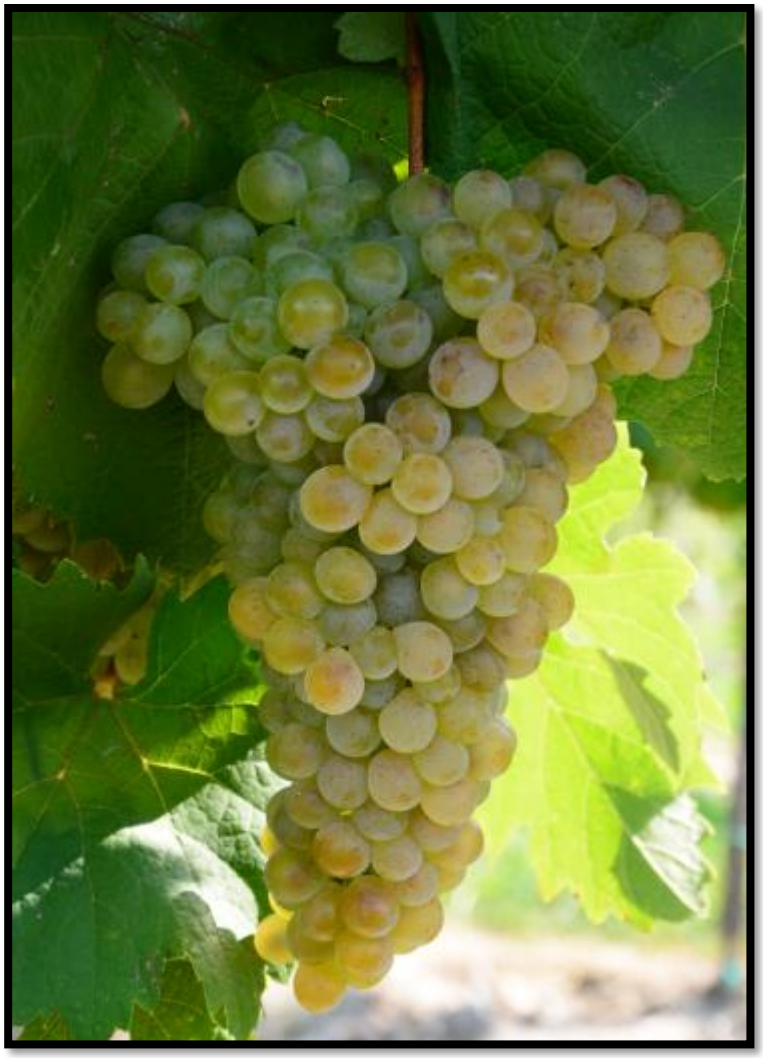

Figure 4. Bunch of Resilia

Another variety to be registered is **Trasemis** (code UD-208.010), a white grape variety obtained by UNIUD and IGA from the cross between SK-00-1/10 and Traminer. The leaf is medium, circular with 5 lobes and V-shaped base petiolar sinus. Medium conical clusters, tendentially compact with one or two wings. The berry is medium small of globose shape. Yellow rose coloured rather thin skin with medium-to-high pruinosity. Soft pulp with Traminer-like flavour. The production is medium, the bunch is larger, with smaller grapes in comparison with Traminer. The bud break-flowering-veraison periods are later than in the case of the noble parent Traminer and, consequently, the ripening is about 3 days later as well. On a sensorial level Trasemis wine is very similar to the parental variety Traminer. The aromatic profile shows a good intensity of tropical, spices, citrus, and floral aromas, in particular notes of rose. Higher content of β-damascenone and β-phenylethanol, when compared to Traminer, are responsible for pronounced notes of rose and violets. The wine has remarkable

freshness, persistence, and structure. It is suitable to produce high-quality perfumed wines with short periods of refining.

Figure 5. Bunch of Trasemis

Table grapes

With a production of about 1.2 million tons of table grapes, Italy ranks sixth as a producing country worldwide after China, USA, Iran, Turkey and Egypt. About 60% of Italian table grapes are produced in Puglia. The most cultivated varieties are seeded: Italia, Victoria and Red Globe. In recent years, there has been a strong interest in the cultivation of seedless varieties, whose origin comes frequently from outside the EU. For the future, a gradual replacement of the seeded varieties is foreseen in favor of the seedless ones, which better respond to market needs (especially in Northern Europe which represents a very important market for Italy) and are better suited for the preparation of food products.

Figure 6. VCR's table grapes tasting

Unfortunately, many seedless varieties spread on the market have problems of adaptation to our environments, as they are obtained in foreign countries characterized by different soil and climatic conditions; consequently, the goal is to obtain new seedless grape varieties suitable for our territories.

In recent years, the VCR program for the creation of table varieties with resistance to diseases and abiotic stresses has also been intensified, with naturally large berry sizes, preferably seedless, with good pulp consistency, good resistance to transport and storage. Thirty-six new high quality genotypes have been selected by VCR technicians and are awaiting further evaluation at an experimental facility in Southern Italy. About 8500 seedlings are still being evaluated within the VCR Research Center.

Rootstocks

An equally important and interesting line of research is the creation of new rootstocks to respond to the needs and emergencies of modern viticulture. The climatic trend of recent years and the repercussions that environmental stresses have on grape production and the quality of musts, have made it increasingly clear how much necessary is having tools capable of "mitigating" the effects of climate change and other abiotic stresses, such as the extension of soil salinity. To counteract the effect of such unstable and fluctuating seasonal trends, with the succession of periods of very strong drought, excessive and concentrated rainfall phenomena, it is necessary to resort to extremely "plastic" rootstocks, able to guarantee a stability of production and quality of the grapes and consequently of the wine even in environmental conditions that can be very different from year to year. These characteristics are hardly found in rootstocks used today, since their creation and selection, which dates back to over a century ago, had other objectives, as the needs of viticulture at the time were different.

A first response (since 1980s) to these new needs was given by the farsighted work of creation and selection of new rootstocks of the University of Milan, which started a crossbreeding program aimed at obtaining new rootstocks with greater efficiency in the use of mineral elements, with particular reference to iron, potassium and magnesium. The result of this intense activity culminated in the identification of four new rootstocks: M1, M2, M3 and M4 and their registration in the National Register of Vine Varieties (Official Gazette No. 127 4/06/14).

The rootstocks of the "M" series are already available to winemakers, also for the initiative of a qualified group of Italian wineries that set up Winegraft S.r.l., with the aim of supporting research and development activities in the field of agriculture in general and in particular in the wine sector and to promote the commercial development of Research products. The multiplication and marketing of the rootstocks of the M series has been entrusted by Winegraft as a world exclusive to Vivai Cooperativi Rauscedo.

Aware of the significance of this important research topic, starting from 2015, the VCR have launched, also for rootstocks, their own genetic improvement program, to offer the national and foreign wine world a new range of solutions to the numerous problems that afflict viticulture. The rootstocks of the future must have better hardiness, moderate vigor and greater efficiency in the absorption of nutrients; particular attention is paid to the ability to withstand abiotic stresses, such as high levels of limestone, salinity and drought, and biotic stresses such as virosis vector nematodes and agrobacterium. Last but not least, the new rootstocks must ensure high grafting yields and

minimize the phenomena of disaffinity, incompatibility and deterioration that can be observed with certain scion-rootstock combinations.

Currently, over 400 new genotypes resulting from 21 controlled cross combinations between commercial genotypes and new selections are being evaluated at the VCR Research Center. Normally, a genetic improvement process foresees several phases through which to select only the plants that demonstrate to have inherited the characteristics of interest; the greater the number of characters to be evaluated, the greater the number of tests necessary to screen the new genotypes obtained by crossing. In the case of rootstocks, this process requires a large number of tests since there are many characteristics that we want to combine in a single individual.

The first phase of evaluation concerns the presence of the fundamental prerequisite, namely resistance to phylloxera: in this regard, a first selection was conducted on the basis of direct observation of the root system and the possible presence of galls and aphids.

Figure 7. Observation of the root system for the possible presence of phylloxera galls and aphids

Subsequently, vegetative development and wood yield will be evaluated on genotypes resistant to phylloxera to establish their aptitude for multiplication. The next step will be to test, in different climates and soils, the level of resistance to the most interesting abiotic (active limestone, salinity, drought) and biotic stresses and the yield in the nursery through compatibility tests with varieties of interest.

Due to the increasingly stringent phytosanitary regulations, VCR aims to study a further character, the resistance to GFLV or grape fanleaf virus. This virus causes deterioration and loss of production

with strong economic damage for the winegrower. It is a virus transmitted by a nematode that lives in the soil, the *Xiphinema inde*x; the elimination of the nematode from the soil is quite difficult and expensive both in economic and environmental terms. For this VCR tries to select new rootstocks resistant to parasite attacks and able to block the development of the virus. A preliminary study conducted at the VCR Research Center has made it possible to identify some genotypes that seem to have a certain level of tolerance towards the viral pathogen. The selection process will also make use of modern molecular screening techniques in order to reduce evaluation times, which, as mentioned, can require over 20 years of experimentation. The commitment of VCR is to offer rootstocks that collect the greatest number of quality characters within themselves to face the new challenges of the viticulture of the future.

Resistance donors

Another important issue that the Research is dealing with is the establishment of new pre-breeding resistance donors. The new resistance donors bred by VCR have been obtained through numerous backcrosses with *V. vinifera* and resistant varieties more performing than those available to date, characterized by very high resistance to downy mildew and powdery mildew, good tolerance to dead arm and black rot, good agronomic characteristics and high enological potential.

The new generation VCR donors contain numerous (at least six) genes of resistance to downy mildew and powdery mildew, some of which are in homozygous state, thus ensuring the potential transmission of high resistance to the offspring.

Currently there are more than 3000 seedlings resistant to downy mildew and powdery mildew in the field. The presence of the new sources of resistance is confirmed through molecular analyzes, while any tolerances to secondary diseases and abiotic stresses are evaluated in the field. Only donors with high quality wine and good agronomic characteristics are then used in the genetic improvement process.

Defense of resistant varieties

In order to limit the number of interventions as much as possible and at the same time to favor their effectiveness, it is strongly recommended to use forecasting models designed to identify the periods of greatest infectious risk. These preventive treatments are of fundamental importance, both in order to avoid the appearance of hypervirulent/highly aggressive fungal strains, and to ensure effective control of the main secondary diseases, in particular dead arm (*Phomopsis viticola*) and black rot (*Guignardia bidwelli*).

The correct phytosanitary management of resistant varieties must begin by taking into consideration all the intrinsic characteristics and criticalities of each territory but, above all, must be set on the basis of vineyard history concerning the number of treatments carried out on average and the incidence of individual pathogens in the different microareas.

To set up a correct defense of resistant varieties it is necessary to take into account the following aspects:

1. all resistant varieties, in relation to the resistance genes present and their specific functioning in certain pedo-climatic conditions, exhibit different levels of effectiveness;
2. these varieties may still show spots and/or necrosis caused by the attack of downy mildew and/or powdery mildew, but unlike traditional varieties, the resistance genes present in them will allow the rapid recognition of the pathogen and the activation of specific defense mechanisms that block the course of the disease;
3. depending on the specific pedo-climatic conditions and the trend of the vintage, the use of these varieties allows to obtain a conspicuous reduction in the number of phytosanitary treatments but does not allow their complete elimination; this concept is of fundamental importance in order to avoid the accumulation of inoculum and the appearance of new strains capable of overcoming the resistance of the vine and becoming highly aggressive;
4. the recommended treatments are also used to avoid the appearance of other diseases (black rot, dead arm etc.) controlled by the treatments against downy mildew and powdery mildew in traditional vineyards.

In general, taking into account the many pedo-climatic variables intrinsic to each microclimate, the use of varieties resistant to downy mildew and powdery mildew can allow a reduction of phytosanitary defense interventions equal to about 70% compared to those necessary for conventional varieties in the same territory.

Sustainable solution

The sustainability of wine production is, to date, the topic of main interest of world public opinion and of all operators in winemaking industry.

The concept of sustainability consists of three elements: a) economy, b) society, c) environment. It is therefore possible to speak of sustainable development only when it is possible to guarantee economic growth and profitability at the same time as environmental protection and greater social equality.

These objectives must be pursued and achieved by facing the consequences related to climate change; the forecast statistical models developed for the next 30 years estimate an increase of 1.5 - 2.5 ° C in the average annual temperature, presumably leading to an advance of the various phenological phases of about 10-15 days. In the long run, this new scenario will drastically change the physiology of plants causing phenomena of water shortages, shifting of phenological phases, oxidative effects on photosynthetic activity, imbalances in the synthesis of secondary compounds and greater virulence of pathogenic organisms.

The answers and solutions to this scenario cannot be, as has happened in recent decades, exclusive to chemistry; by doing so, the goal of sustainability would fail but above all it would compromise the future of the generations to come. The impact of agriculture on the environment is currently very high especially in terms of the use of plant protection products.

The role of Research and Innovation in this context assumes a fundamental importance in experimenting and proposing solutions for new viticultural models, which can lead to a significant reduction in vineyard inputs: new varieties resistant to pathogens, new rootstocks and innovative cultivation practices must guarantee a significant reduction in phytosanitary treatments, less use of irrigation and fertilization and consequently lower production costs, without compromising the quality of the grapes and the characteristics of the wine obtained, in order to maintain a position of value and global prestige of the Italian wine sector .