SETTING UP NEW TOOLS TO REDUCE THE DURATION OF THE GRAPEVINE BREEDING PROCESS : MERCIER EXPERIENCE

Authors: Camille MIETTON[1*], Olivier ZEKRI[2], Faustine MARTINEZ[2], Pierre VIDEAU[1], G. MERCIER[2]

[1]*NOVATECH SAS, Le Champ des Noëls, 85770 Le Gué de Velluire, France*
[2]*Mercier Frères SARL, 16 rue de la Chaignée, 85770 VIX, France*

*Corresponding author: *camille.mietton@mercier-groupe.com*

Abstract:

Context and purpose of the study

Since some years, the French wine sector faces strategical challenges, all linked to climate change. Multiple issues have been observed like diseases development, early frost, drought, change in the precocity and maturity of grapes, each one resulting in loss of productivity and yield. In France, the varieties proposed today by nurseries are historical varieties that are not well adapted to those changes. Therefore, Mercier Frères, one of the leading grapevine nursery, has decided to start its own research programs, with the help of its laboratory Novatech, to answer the growing demand for new grapevine varieties.

Discussion

The NATHY program ("Naturellement Résistant") consist in creating new varieties by traditional breeding, with the help of molecular tools and new production techniques. In partnership with breeders around the world, the first aim is to develop and propose resistant varieties first to the most harmful fungi: downy and powdery mildew, and black rot. Traditional breeding of perennial species like grapevine can take 25 to 30 years. The challenge for the company is to reach a breeding cycle of 10 years from the seed to the registration of the variety. To achieve this goal, the combination of multiple tools is required. Marker assisted selection allows us to detect resistance genes in the early life of the plant, and to discard rapidly genotypes that don't meet our expectations. Another major improvement is to reduce the time for scion production. A tomato-like production system has been developed, enabling the plant to produce scions in only one year after planting, instead of 3 years in a classic field process. Multiple other tools are tested to study all the ways to reduce the breeding cycle. With this rupture innovation program, we hope to create new genetic resources meeting growers' expectations about climate change challenges.

Keywords: Viticulture, Climate change, Resistant varieties, Greenhouse production, Marker Assisted Selection.

1. Introduction

Grapevine is one of the most important fruit crops in the world. In France, viticulture represents 17% of the value of agricultural production, for only 3% of the areas used. And 10% of the world's vineyard surface is planted in France, with nearly 790,000 hectares (Ministère de l'Agriculture et de l'Alimentation, 2022). It is also one of the crops that consume the highest quantity of phytosanitary products, which no longer corresponds to societal expectations in terms of ecology. Varietal selection with the contribution of new varieties could make possible supporting winegrowers towards viticulture that meets the challenges of climate change and agroecological transition. The creation of varieties that are resistant to the main diseases and resilient to climate change is an essential lever in the face of these challenges. With this type of varieties, we could go from an average of 14 annual fungicide treatments (Agreste, 2021), to only twice around the flower. It is enough to limit the development of diseases such as downy or powdery mildew. Unfortunately, there are still too few of these varieties on the market to properly meet all the expectations of winegrowers, specific to each winegrowing area.

Several breeding initiatives in Europe, mainly driven by academic institutes, are going on today to create new genetic resources, mainly focused on fungal diseases resistance: WBI in Friburg (Weinmann, 2019), JKI in Geiweilerhof (Eibach and Töpfer, 2015), university of Udine (Foria et al., 2018) or Trento (Vezzulli et al., 2018) in Italy, INRAE in France (Merdinoglu et al., 2018) and many other programs (Reynolds, 2015). All those programs, based on multiple crossing strategies need between 20 and 30 years to be able to potentially reach the market (Töpfer et al., 2011).

However, winegrowers need fast solutions to comply to governmental and societal expectations. Since 2018, Mercier Frères French nursery has obtained the agreement to be the first French private grapevine breeding company. Since, a breeding program aiming at reducing the time to create a new grapevine resistant variety have been settled. Specific techniques and technologies, as marker assisted selection, pathogenic assays, or nano and microvinification, are used in this process. A new growing method for grapevine is also a key process to reduce breeding times. We aim to reduce from 25 years in a classical grapevine breeding program to only 10 years in our improved breeding program (figure 1), also combining testing and registering process.

2. Breeding program overview

2.1. *Breeding targets*

Our breeding targets are very similar to other breeding program in the European wine sector. It aims to propose to winegrowers solutions to technical impass caused by climate change and diseases. We have chosen three key criteria that have to be reached to select a new genotype:

1. Polygenique resistance, with a minimum of two resistant genes for powdery mildew and two resistance genes for downy mildew. This ensures the durability of the resistance genes, so they could last longer.
2. Minimum yield of 90hl/ha, which is enough to guarantee a sufficient quantity of grapes to face climatic hazards. Winegrowers could adjust yield to fit the quality they need.
3. Enough gustatory quality to vinify the new variety alone.

2.2. *Genetic material*

In our breeding program around 1200 genotypes have been acquired during several years. Those varieties have a very diverse genetic background, coming from partnerships with private and academic institutes from all over the world. We chose an "editor" strategy, so we can rapidly answer the growing demand of winegrowers. We aim to add value to undeveloped genotypes of grapevine breeders that could meet our targets.

Our main partner is Valentin Blattner, a Swiss grapevine breeder. Most of our genotypes comes from his breeding program and have many pyramided resistant genes. We also have partnership with Julius Kühn Institute in Germany, Udine university and Edmund Mach foundation in Italy, and UC Davis in the United States. Figure 2 shows genes combination of our genetic material, achieved thanks to the diversity of origins.

Two types of material could be differentiated: genotype in selection process, and varieties already registered in another European country. This determines the type of contract and our implications in the registration process. We could be distributor as for our first NATHY variety, the NATHY Sauvignac, or co-obtentor if we have participated to the creation and registration of the variety.

3. Breeding methods

The originality of our breeding program is in our willing to reduce grapevine breeding times from 25 to 10 years. Our methods don't differ much from those already used from other actors of grapevine selection.

3.1. Laboratory technologies

Marker assisted selection have been developed at Mercier Novatech laboratory in the past years. It is done systematically at the arrival of the genotype. It has been successfully used to select resistant genotypes. Pyramiding resistances is the key for stability and durability of resistance in the perennial crop that is grapevine (Zini et al., 2019). Genotypes with more than two resistant genes for powdery mildew and two resistant genes for downy mildew are selected for further detailed studies of their field resistance and agronomic characteristics and are very good candidate for a new resistant variety. On the market, very few genotypes have a high number of stacked genes for powdery and downy mildew (Töpfer and Trapp, 2022). Backcrosses need to be carried on to increase the potential number of new resistant varieties with good wine quality traits.

Pathogenic assays for downy and powdery mildew can be done during the first month of growth of the genotype. Results will be compared with field observations. Only genotypes that present a low growth of mildews in vitro and in the field are selected for the next steps. Research have shown that in vitro assays are a good indicator of leaf resistance in fields, and are efficient for the rapid, reliable, and economical identification of resistant hybrids in grapevine breeding programmes (Prajongjai et al., 2014). It also confirms that the use of isolates coming from the vineyard is more accurate, because it represents the actual diversity (Vezzulli et al., 2018). Findings also demonstrate that leaf disc bioassays are not a robust indicator of field resistance/susceptibility on clusters, showing that field evaluation stay a key-work for resistance determination (Vezzulli et al., 2018).

3.2. Small volumes vinification

One of the most important steps for grapevine breeding is to determine the capacity of the genotype to create superior quality wine. The first grapes are growing generally during the 3rd year after the plantation, and at least 3 years of wine evaluation need to be done to select a good candidate. Nano and microvinification processes have been developed to accelerate this key step. Nanovinification can be done on a few bunches and produce less than 5L of finished wine. This technic is used standardized for all the genotypes and permit to discard genotypes with important negative wine traits, like hybrid fox flavor. Microvinification is more common and relate to around 1hL of finished wine. It allows us to work with intermediate amount of grape and select genotypes with at least the same wine quality than standard wine varieties. It can be standardized or adapted to the genotype if we have identified a typicity. For both volumes, at least three years of vinification are done to ensure that the wine quality is not dependent of environment variations.

3.3. Greenhouse production

In 2019, Mercier group have launched a new way to produce motherblock scion: soilless greenhouse cultivation (figure 3). This permit to reduce drastically production times. It produces grafting material in only one year instead of 3 years for field motherblocks (unpublished own observations). In our breeding program, we could plant registration testing block (90 plants on 2 sites) two years after the crossing. This is a major advantage to decrease breeding process duration and rapidly observe performance in large plot. It also allows to rapidly produce enough material for commercialization after the registration of a new varieties, to rapidly meet the market needs.

4. Conclusions

The combination of several improvement in selection and production process could permit to reduce the duration of a breeding program for grapevine. From marker assisted selection to optimized production processes, some critical steps in grapevine breeding are studied. For the first time 22 genotypes will be tested for an evaluation/registration combination, hoping to register a new grapevine resistant variety by 2028.

Other tools, as genome editing, are studied to improve grapevine characteristics for resistances and climate change adaptation. This technique is still in its infancy, and it will take time for the first edited plants to reach the status of current traditionally bred new cultivars in terms of market readiness, but every option needs to be considered for the improvement of our vineyards.

5. Litterature cited

AGRESTE, 2021. Enquête pratiques culturales en viticulture en 2019, IFT et nombre de traitements n°19 (Paris: Ministère de l'Agriculture et de l'Alimentation). <https://agreste.agriculture.gouv.fr/agreste-web/download/publication/publie/Chd2119/cd2021-19_PK%20Viti2019.pdf>

EIBACH, R., TÖPFER, R. , 2015. Traditional grapevine breeding techniques. In Grapevine Breeding Programs for the Wine Industry, (Elsevier), pp. 3–22.

FORIA, S., MONTE, C., TESTOLIN, R., DI GASPERO, G., CIPRIANI, G., 2018. Pyramidizing resistance genes in grape: a breeding program for the selection of elite cultivars. In XII International Conference on Grapevine Breeding and Genetics 1248, pp. 549–554.

MERDINOGLU, D., SCHNEIDER, C., PRADO, E., WIEDEMANN-MERDINOGLU, S., MESTRE, P., 2018. Breeding for durable resistance to downy and powdery mildew in grapevine. OENO One 52, 203–209.

MINISTERE DE L'AGRICULTURE ET DE L'ALIMENTATION, 2022. La viticulture française. <https://agriculture.gouv.fr/infographie-la-viticulture-francaise>. Accessed 4th April 2022.

PRAJONGJAI, T., POOLSAWAT, O., PORNBUNGKERD, P., WONGKAEW, S., TANTASAWAT, P.A., 2014. Evaluation of grapevines for resistance to downy mildew (Plasmopara viticola) under laboratory and field conditions. South African Journal of Enology and Viticulture 35, 43–50.

REYNOLDS, A.G., 2015. Grapevine breeding programs for the wine industry: traditional and molecular techniques (Oxford: Woodhead Publishing).

TÖPFER, R., HAUSMANN, L., HARST, M., MAUL, E., ZYPRIAN, E., EIBACH, R., 2011. New horizons for grapevine breeding. Fruit, Vegetable and Cereal Science and Biotechnology 5, 79–100.

TÖPFER, R., TRAPP, O., 2022. A cool climate perspective on grapevine breeding: climate change and sustainability are driving forces for changing varieties in a traditional market. Theoretical and Applied Genetics 1–14.

VEZZULLI, S., VECCHIONE, A., STEFANINI, M., ZULINI, L., 2018. Downy mildew resistance evaluation in 28 grapevine hybrids promising for breeding programs in Trentino region (Italy). European Journal of Plant Pathology 150, 485–495.

WEINMANN, E., BOOS, M., EHRET, P., FLUBACHER, L., SCHNEIDER, C., VEITH, L., 2019. Breeding of new disease-tolerant grape varieties–Viticulture in times of climatic change. In BIO Web of Conferences, (EDP Sciences), p. 01035.

ZINI, E., DOLZANI, C., STEFANINI, M., GRATL, V., BETTINELLI, P., NICOLINI, D., BETTA, G., DORIGATTI, C., VELASCO, R., LETSCHKA, T., 2019. R-loci arrangement versus downy and powdery mildew resistance level: a Vitis hybrid survey. International Journal of Molecular Sciences 20, 3526.

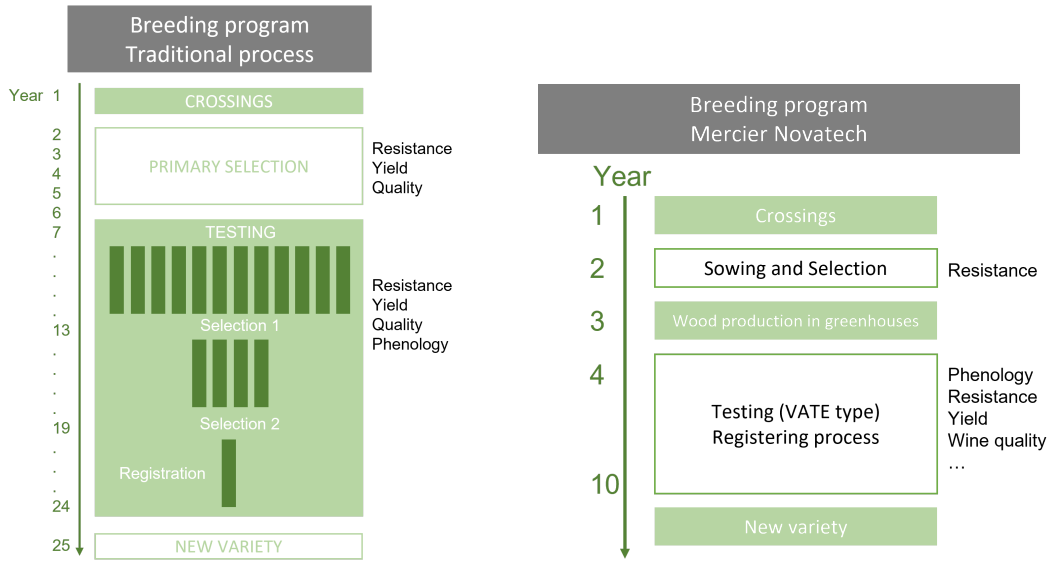

Figure 1: Traditional breeding program versus improved Novatech breeding program.

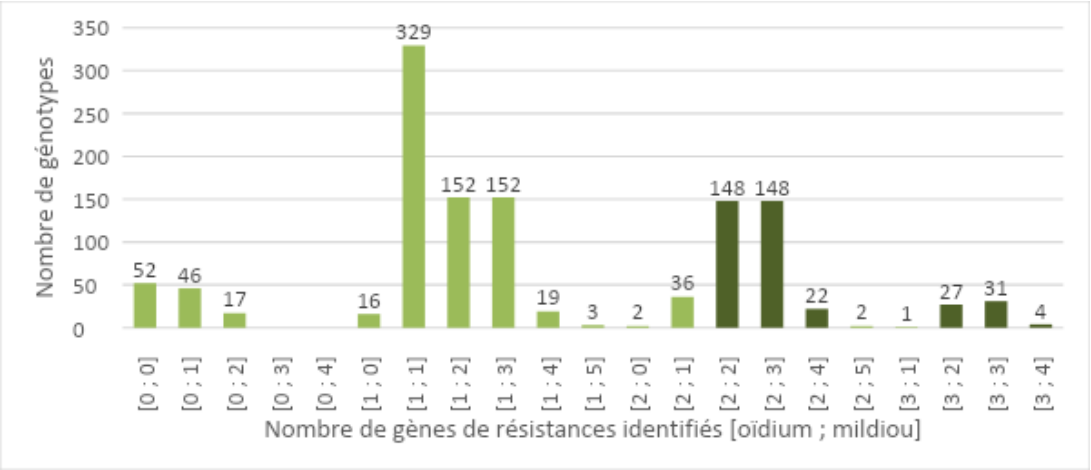

Figure 2: Number of genotypes in each category of resistance genes; In light green, genotypes with less than 2 resistance gene for powdery or downy mildew; In dark green, genotypes with more than 2 resistance genes for powdery and downy mildew.

Figure 3: Wood production of grapevine in greenhouse