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International Viticulture and Enology Society - IVES
Institut des Sciences de la Vigne et du Vin
210 chemin de Leysotte 33882 Villenave d'Ornon - France
Phone +33 (0)5 57 57 59 72
Cell. + (33 (0)6 65 37 66 68
www.ives-openscience.eu
twitter.com/ives-openscience

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Understanding Esca: watch out for the grafting type

Sourced from the research article "Impact of grafting type on Esca foliar symptoms"[1]

>>> Black measles in English, Esca in French, Escha in Italian, Yesca in Spanish, Iska in Greek... This nightmare for winegrowers around the world creates confusion about its development and characteristics. Nevertheless, research progress has been made, and a recent scientific survey addressing the impact of grafting types on foliar symptoms added a new piece to the complex puzzle of understanding this disease. Full cleft grafts, directly made on the plot, have much better results. <<<

Esca has been one of the most alarming threats in vineyards worldwide since the very beginning of winemaking. Although extensive research efforts worldwide have focused on the study of this complex syndrome, no satisfactory control measures have yet been found. Biotic and abiotic parameters that can favour or slow down its development are well known and multiple, i. e. rootstock and grape variety choice, training system, pruning type, age of the plot, water stress or soil type ; however, the difficulties in reproducing the symptoms under controlled conditions limit advances in understanding and controlling this syndrome.

The overall quality of plant material has frequently been questioned by winegrowers for its possible influence on Esca expression. Certain grafting types are particularly suspect. Even if researchers have shown over the years that grafting damages the vine and thus increases the opportunity for contamination by the local microbiome, no study has confirmed the suspicion on the technics applied. This likely explains why a team of scientists[1] from the University of Bordeaux, the Institute of Vine and Wine Sciences (ISVV), Inra and Bordeaux Sciences Agro, supported by Worldwide Vineyards, decided to study the impact of grafting types on Esca foliar symptoms[2].

Their observations were conducted over a two-year period on plots located in two French winegrowing regions (Bordeaux and Provence) and planted with Cabernet-Sauvignon and Mourvèdre, respectively. These two grape varieties were chosen because they are representative of their regions and sensitive to Esca. The researchers analysed *in situ* the expression of its symptoms on three grafting types: omega and whip-and-tongue (used in nurseries), and full cleft grafts (directly made on the plot). In order to obtain rapid results, they monitored a fifty-plot network, planted between 1950 and 2000. Hence, Esca, which takes several years to show up, was immediately noticeable.

Full cleft grafted vines are much more resistant

Over the two-year study period and in both grape varieties, full cleft grafted vines showed significantly lower percentages of Esca foliar symptoms than the omega and whip-and-tongue grafted ones. In fact, during the first year of the study less than 1 % of full cleft grafted vines showed foliar symptoms while more than 6 % of the vines grafted using the other two methods were affected. In 2014, the phenomenon was even greater with still less than 1 % of affected full cleft grafted vines against more than 8 % for the whip-and-tongue and more than 10 % for the omega vine plants. The same significant effect of the grafting type has been observed by the researchers with regard to the apoplectic form of the disease, which impacted the omega and whip-and-tongue grafted plots more significantly than the full cleft ones.

Apoplectic form VS foliar symptoms

The apoplectic form results in rapid dieback and death of the entire vine, especially in the summer.
Foliar symptoms of Esca – typical of its slow form – are interveinal yellow stripes in white cultivars and dark red ones in red cultivars. Symptomatic leaves can dry out and drop (necrosis).
On berries, dark spots may appear and in severe cases, berries crack and dry or are damaged (more common in northern America and not part of the survey).

Contamination occurs in the early years

Why such differences ? These results could be rooted in the first years of the grape vines' life. High rates of fungal

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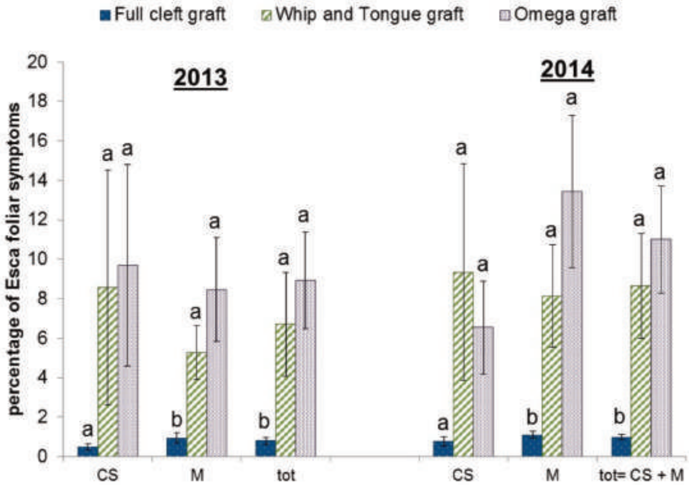
a. Full cleft graft b. Whip-and-tongue graft c. Omega graft



Mean percentage of Esca vines per year and per variety (±standard deviation) (« Total » is the mean of Cabernet-Sauvignon (CS) and Mourvèdre (M) plots). Analyses were carried out per year and per variety. Different letters above bars indicate significant differences between grafts (at $P < 0.05$).

contamination have frequently been observed by researchers along the breeding process in nurseries (hydration, disbudding, callusing, rooting, etc.)[3]. As full cleft grafts are made directly on the rootstocks in the field, these vines are not subject to these "hostile environment" manipulations, giving them a better chance to remain healthy.

Other assumptions can explain this conclusion, such as the better quality of the full cleft graft method thanks to the larger contact surface between the rootstock and scion cambiums that minimises necrosis risk and enhances the future plant sap circulatory system set-up. Furthermore, this operation is performed on already well-rooted rootstocks, thus giving the vines the opportunity to allocate maximum resources to the development and robustness of their new vascular systems.

Whip-and-tongue is not a good alternative

Please note that the authors of the survey warn us about potential bias in their statistics, due to the age difference between the omega grafted plots (around 20 years old) and the other two grafted plots (more than 40 years old). Indeed, the greatest Esca expression is known to impact vineyards aged between 15 and 25 years[5]. Yet, in this study only the full cleft grafting plots and the whip-and-tongue ones were the same age, guarantying the validity of the comparison. The omega grafted ones were younger, as a result of the more recent development of this technic that replaced the others at the beginning of the 1980s because of its lower production cost. Therefore, only the comparison between the full cleft grafting plots and the whip-and-tongue ones is scientifically robust, and no definitive judgement can be made on the omega graft. However, these results indicate that the whip-and-tongue technic, mechanically performed in nurseries, would not be a good alternative to the omega technic.

The assumptions on the omega graft must be confirmed by new experiments implementing these three grafting types on the same plot. Surveys are underway but it will take time to observe the first Esca foliar symptoms and further unravel the factors involved in this syndrome. ■

Huge differences between plots

The authors of the study have highlighted a strong local effect. Reported rates of vines infected by the slow form of Esca ranged from 0 % to more than 40 %, notably in the plots grafted with omega and whip-and-tongue methods. The literature suggests that this could be due to the planting of infected batches, produced intensively by nurseries in poor sanitary conditions[4].

Séverine Mary[1], Coralie Dewasme[1], Pascal Lecomte[2], Marc Birebent[3], Julien Dumercq[4] and Jean-Philippe Roby[5]

[1]Univ. Bordeaux, Vitinnov, ISVV, 1 cours du Général de Gaulle, 33170 Gradignan, France
[2]SAVE, INRA, Univ. Bordeaux, 33175 Gradignan cedex, France
[3]Worldwide Vineyards, BP 16, Valmoussine, 83660 Carnoules, France
[4]International Viticulture and Enology Society
[5]EGFV, INRA, Univ. Bordeaux, 33175 Gradignan cedex, France

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Viticulture in a changing climate: solutions exist

>>> Grape growers have always cultivated vineyards in challenging environments, adapting their practices to sometimes very difficult local conditions. Climate change, as a new player, is modifying the terroirs' characteristics rapidly and irremediably, giving viticulturalists major new challenges to face. <<<

The vine is an agricultural crop of major economic importance, in particular in Mediterranean countries. Like for any other crop, yields depend on soil fertility and climatic conditions. However, in viticulture, environmental conditions (soil, topography and climate[1]) are even more important because they not only determine yields, but also grape composition, as well as sensory attributes and quality of the wines made which impacts the price at which they can be sold.

Climate change: increasing temperatures…

High quality viticulture is only possible in a limited range of temperatures. Indeed, optimum wine quality is obtained when the ripening period of the grapes occurs in temperate conditions at the end of the growing season. When maturation happens too late in the season, grapes tend to be unripe at harvest time with low sugar to acid ratios, which results in green and acidic wines. When grapes reach maturity early in the season, when temperatures are still very high and days are long, the final product lacks freshness and aromatic complexity. Optimal conditions for the production of dry table wines are generally met when the grapes reach full ripeness between the 10th of September and the 15th of October on the Northern Hemisphere (10th of March-15th of April in the Southern Hemisphere): temperatures are still high enough to obtain an optimal maturity, but not too high to preserve a balanced sugar to acid ratio in the grape juice and freshness and a complex aromatic expression in the wine.

With increasing temperatures, grapes tend to ripen earlier in the season. Growers need to adapt to this situation by delaying phenology, in order to keep the harvest in the ideal window. The most efficient way is to choose later ripening varieties. This can be done, in a first step, by increasing the proportion of these varieties among local ones (e.g. more Cabernet-Sauvignon and less Merlot in the Bordeaux area, more Mourvèdre and less Syrah in the Languedoc area). Late ripening clones and more vigorous rootstocks are also an option. When even the latest ripening local varieties reach full ripeness too early, planting of late ripening non-autochthonous varieties can be an option.

Furthermore, training systems can be adapted by increasing trunk height, which will slightly reduce maximum temperatures in the fruit zone. In addition, maturity delaying canopy management practices include reducing leaf area to fruit weight ratio and limit leaf removal. Late pruning is

Bushvines in Aragon (Spain) a training system which is perfectly adapted to drought.

What about the soil?

Soil water holding capacity (SWHC) can, to a certain extent, compensate for climatic drought. This is why in dry climates vineyards should be established on soils with at least medium SWHC. This parameter is related to rooting depth. Deep soils have greater SWHC. Deep soil ripping before plantation also increases rooting depth.

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Widely used rootstocks from the less resistant (left) to the more resistant (right) to water stress

also an option to delay vine phenology[2]. All these adaptations to higher temperatures are environmentally friendly and have little or no impact on production costs.

...versus increased drought

The vine is a Mediterranean species which is highly resistant to drought. It can be cultivated with dry farming in extremely dry climates, down to 400 mm of rain per year, or even slightly less. Yield is negatively impacted, but not necessarily quality: many famous wines are produced worldwide in these conditions without irrigation, like Henschke Hill of Grace in Australia and Dominus Estate in Napa, California.

Although not every single growing place will be impacted in the same way, most of them will have to face more frequent and severe droughts during the growing season in the years to come. The use of resistant plant material (grapevine varieties and rootstocks) is an environmentally friendly and cost effective option to decrease vulnerability of vineyards to water deficits. Among widely used drought resistant rootstocks, 110 Richter has the advantage of possessing high quality performances. In extreme situations, 140 Ruggeri is even more resistant[3] to water stress. In general, these adapted rootstocks also promote grape yields. Similarly, important differences do exist among grapevine varieties[4]. Empirical knowledge exists among growers, who know that Grenache, Carignan and Cinsault are drought tolerant, while Tempranillo, Syrah, Merlot and Sauvignon blanc are not. Most Mediterranean varieties are less affected, because they have been selected by growers for this particular trait.

Adapted training systems already exist

Over centuries, wine growers of the Mediterranean basin have developed a training system which is perfectly adapted to drought: the so-called Mediterranean gobelet or bushvine. It makes it possible to cultivate vines in extremely dry conditions. Although gobelet trained vines generally produce low yields, they are easy to grow at low production costs.

Research progresses needed...

- Unravel the underlying physiological mechanisms of resistance to water deficit. This would help growers to optimize the use of drought resistant varieties in dry environments. The revival of local varieties adapted to these conditions can be an interesting challenge to detect some that may outperform Grenache and Carignan in their tolerance to drought.
- Find or generate rootstocks that may perform even better than 140 Ru or 110 Richter in dry conditions.
- Create a mechanical harvester for the gobelet training system to reduce labor costs.

It is a pity that these highly drought resistant vineyards are pulled out and replaced by trellised vines with increased water consumption, in a context where this resource is becoming increasingly scarce. One of the reasons is that there are currently no available mechanical solutions to pre-prune and harvest these vines. Another option is to reduce planting density in trellised vines[5]. When light interception by the canopy is limited through wider spacing, transpiration and water consumption are reduced.

Irrigation is an option, but raises questions about sustainability

To avoid yield losses due to drought, irrigation is also an option. However, it cannot be considered as a sustainable practice, because of increased competition for water resources, for instance with drinking water and use for food crops. Furthermore, in some cases (when winters are dry), it can lead to augmentation of vineyards' soil salinity, making them improper for cultivation in the long run. Lastly, only deficit irrigation should be conducted, with precise vine water status monitoring (e.g. by measuring stem water potential) in order to limit, as much as possible, the amount of resource used. However, even with fine-tuned management, the blue water footprint of an irrigated vineyard is generally at least 100 times higher compared to a dry farmed vineyard. ■

Cornelis van Leeuwen, Jean-Philippe Roby and Nathalie Ollat

UMR Ecophysiology and Grape Functional Genomics (EGFV), Bordeaux Sciences Agro, Inra, Univ. Bordeaux, ISVV, 33882 Villenave d'Ornon, France

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Bio-modulating wine acidity: The role of non-*Saccharomyces* yeasts

Sourced from the research article "Use of nonconventional yeasts for modulating wine acidity"[1]

>>> In recent years, wine consumers have been looking for fruitier wines, with less ethanol, but presenting a good balance in terms of mouthfeel. However, due to the effects of global climate change, wines can be more alcoholic and flatter in terms of acidity. If in the past, non-*Saccharomyces* yeasts were often considered as spoilage yeasts, now they are used to modulate wine composition, namely in terms of aroma and acidity. In this article, the ability of some non-*Saccharomyces* yeasts to modulate wine acidity is reviewed. <<<

Schizosaccharomyces pombe ©Lucia Molnarova

Acids present in wines and their perceived taste

Organic acids are a significant constituent of wines. They present a sour/acid taste, and influence wine stability, color, pH and have a significant effect on the final wine mouthfeel quality. The acid composition and concentration of wines is influenced by many factors, from grape variety and climatic conditions to fermentation process and yeast. Some of the acids are formed in the grape-berries, during berry development, others are formed during alcoholic fermentation (AF) and malolactic fermentation (MLF). During these biological processes, it is prudent to monitor the concentration of organic acids, and a distinction is made between acids directly produced in grapes (tartaric, malic, and citric) and those originating from AF and MLF (succinic, lactic, and acetic acids, among others), Table 1.

Non-*Saccharomyces* yeasts and wine acidity modulation

The main volatile compounds and the organic acids formed/consumed by non-*Saccharomyces* yeasts during grape-must fermentation are described in Table 2.

During MLF, the metabolism of *Oenococcus oeni* can improve the wine sensory characteristics by decreasing acidity. However, the success of MLF is influenced by enological parameters, such as temperature, pH, alcohol content and SO_2 concentration, among others. An alternative to MLF was studied by Benito and coworkers[2] to be used, particularly, in warm viticulture regions such as the south of Spain where the risk of suffering a deviation during the MLF process increases due to the high must pH which may contribute to produce wines with high volatile acidity and biogenic amine values. The mentioned authors used two non-*Saccharomyces* yeasts as an alternative to MLF. Malic acid was consumed by *Schizosaccharomyces pombe* by converting it to ethanol and CO_2 (Figure 1), whereas *Lachancea thermotolerans* produces lactic acid in order to maintain wine acidity balance, especially in wines produced from low acidity musts.

Table 1. Major organic acids present in grapes and wines and their sensory descriptors. Adapted from Vilela[1].

	Major Acids	
	L-tartaric (citrus-like taste)	Produced in grapes
	L-malic (metallic, green-apples taste)	
Fixed acids	Citric (fresh and citrus-like)	
	L-lactic (sour and spicy)	Produced during AF and MLF
	Succinic (sour, salty, and bitter)	
Volatile acid	Acetic (vinegar-like)	

Another malic acid consuming strain, not yet commercialized or produced at an industrial level, is *Issatchenkia orientalis/Pichia kudriavzevii*. In 2014, del Mónaco and coworkers[3] found a *P. kudriavzevii* isolate that was able to degrade L-malic acid in microvinification assays, increasing the pH by 0.2–0.3 units. Furthermore, this yeast strain produced low levels of ethanol and significant levels of glycerol.

L. thermotolerans can produce lactic acid and glycerol during fermentation, and all these interesting features can be a way to address the problems of increased alcohol content/reduction in the total acidity of wines, associated with global climate changes. Moreover, *L. thermotolerans* in the presence of some O_2, by shifting its metabolism more towards respiration than fermentation, is also capable of decreasing wine volatile acidity[4].

At the beginning of AF, many species can grow at the same time in the grape-must and *Candida stellata* spp. have been described in this stage of fermentation. An interesting *C. stellata* feature is its ability to form succinic acid[5]. Succinic acid could positively influence the sensory/ mouthfeel profile of wines with insufficient acidity. Nevertheless, due to its 'salt-bitter-sour' taste, excessive levels would negatively influence wine quality.

Another interesting yeast is *Torulaspora delbrueckii*. An indication of the positive impact of *T. delbrueckii* activity on wine quality was demonstrated by Bely and coworkers[6]

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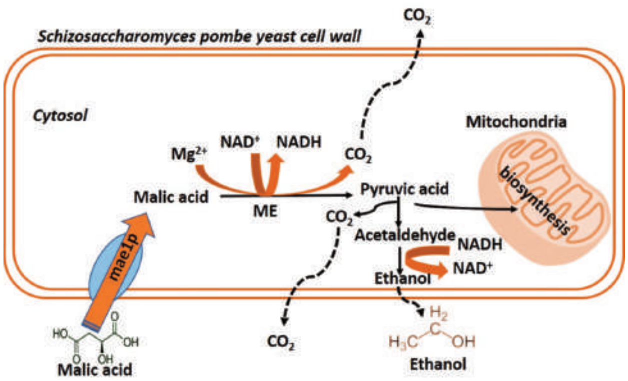

Figure 1. Schematic representation of the maloalcoholic fermentation performed by *Schizosaccharomyces pombe*. Adapted from Vilela[1].

Table 2. Main volatile compounds produced and effect on wine acidity of seven non-*Saccharomyces* yeasts. Adapted from Vilela[1].

Yeast species	Volatile compounds	Effect on wine acidity
Lachancea thermotolerans	2-P henylethylacetate and ethyl lactate	Acidity enrichment (lactic acid) Acidity reduction (acetic acid)
Schizosaccharomyces pombe	Higher alcohols and esters	Maloalcoholic deacidification
Candida stellata	Esters and acetoin	Acidity enrichment (succinic acid)
Torulaspora delbrueckii	Long-chain alcohols, esters, aldehydes and glycerol	Low production of acetic acid
Zygosaccharomyces florentinus *Zygotorulaspora florentina*	Higher alcohols and esters	Low production of acetic acid Some species are able to consume acetic acid
Pichia kudriavzevii *Issatchenkia orientalis*	Esters and higher alcohols	l-malic acid consumption
Starmerella bacillaris *Candida zemplinina*	A higher level of some terpenes, lactones and thiols	Malic acid degradation Reduction of acetic acid in sweet wines Production of pyruvic acid

when fermenting botrytized musts and, afterward, by Azzolini and coworkers[7] in Vino Santo, a sweet wine, due to its low production of acetic acid. Moreover, *T. delbrueckii* in the production of Amarone wine (*Amarone della Valpolicella*), a high-alcohol dry red wine obtained from withered grapes, was able to promote the formation of alcohols, fermentative esters, fatty acids, and lactones, which are important in the Amarone wine flavor[7].

S. pombe and *L. thermotolerans* are presently produced at an industrial level by biotechnological companies. *T. delbrueckii* is commercialized in the form of a pure culture, selected for its properties such as increase in aromatic complexity, mouthfeel, low production of volatile acidity and high resistance to initial osmotic shock. According to the supplier, it is highly recommended for the fermentation of late harvest wines in sequential culture with *S. cerevisiae*.

Zygosaccharomyces spp. are well known for their ability to spoil food and beverages. The fermentative nature of *Zygosaccharomyces* metabolism produces CO_2 that is of concern if the food product is in a sealed container, as the increase in gas can cause the container to leak or, in extreme cases, explode. Haze or sediment can occur in beverages as cellular biomass accumulates, and in some cases, surface biofilms can be formed. The aroma and taste modification can occur by the production of secondary metabolites with sensory impacts on the food or beverage and include acetic acid, esters, and higher alcohols. Nevertheless, some strains are used in the industrial production of balsamic vinegar and other food products.

Recently, Lencioni and coworkers[8] studied the possibility to decrease wine volatile acidity of high-sugar musts, by using *Zygosaccharomyces florentina* and *Starmerella bacillaris* in multistarter fermentations with *S. cerevisiae*. Independently of fermentation temperature, the mixed fermentations performed best to reduce volatile acidity, therefore being a valuable tool for performing fermentation of high-sugar musts.

Final remarks

In conclusion, many non-*Saccharomyces* yeasts present interesting enological properties and when used in single or mixed cultures with *S. cerevisiae*, these yeast species can modulate wine acidity and increase the production of some interesting compounds, such as polysaccharides, glycerol, and volatile compounds, such as 2-phenyl ethanol and 2-methyl 1-butanol.

Nevertheless, if the use of some of the yeast species cited could modulate wine acidity, some can also act as spoilage, through the production of off-flavors, haze or sediment, depending on the environmental conditions. So, a deeper study of the enological traits of these yeasts will provide new data for consideration in the modulation of wine acidity. ■

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Alice Vilela
CQ-VR, Chemistry Research Centre, School of Life Sciences and Environment, Department of Biology and Environment
University of Trás-os-Montes and Alto Douro (UTAD)
Enology Building, 5000-801 Vila Real, Portugal
avimoura@utad.pt

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Defoliation of the vines before or after berry set: Physiological consequences and qualitative factors

>>> Defoliation of the vines consists of eliminating the leaves in the grape bunch zone in a more or less intensive manner. It is a long-proven prophylactic technique that has seen a renewed interest in the current context of the reduction of phytosanitary inputs. However, several questions remain. Which is the optimal period? What is the ideal intensity? What are the risks? Is the mechanization of this process a feasible option? Agroscope has been undertaking defoliation trials in Switzerland since 2010 in order to shed light on these questions. <<<

Study context

The choice of defoliation timing must be undertaken judiciously in regards to the desired results. Effectively, the elimination of adult leaves in full photosynthetic activity will reduce the carbon uptake toward the inflorescences or the bunches at a period that could be critical for the balanced nutrition of the vine and a good ripening of the grapes. The Agroscope research station has set up defoliation trials on five grape varieties – Chasselas, Doral, Pinot noir, Gamay and Merlot – and in three experimental sites in the Lake Geneva region as well as in the Tessin region (South of the Alps). Three defoliation periods were tested – Phenological stage BBCH 57 (separated flower buds) 67 (end of flowering) 77 (bunch closure) – compared to a non-defoliated control test.

Also tested was the intensity of the defoliation on Chasselas 50% or 100% of the grape bunch zone. The reference articles cited present the trials in a detailed manner[3,4,5,6].

Between berry set and veraison (colour change): «Classical» defoliation

The defoliation of the grape bunch zone is generally undertaken during the period of the formation of the bunches – after the berry set and before the veraison (color change) – while the vine is still in its growth phase. It permits the creation of a ventilated microclimate around the grapes so as to efficiently prevent the development of fungal diseases, notably powdery mildew (*Erysiphe necator*) and grey rot (*Botrytis cinerea*). It otherwise fosters a better penetration of phytosanitary products. More the defoliation is intensive (100% in the context of this study) in the grape bunch zone, more it is efficient in combating fungal diseases[5].

Defoliation after berry-set does not affect the harvest yield and has little influence on the composition of the grape must insofar as the leaf-to-fruit ratio – a critical criterion in ensuring the ripeness of the grape – is maintained above 1 m^2 of exposed canopy per kilogram of harvest.

Defoliated Chasselas

A strong compensation capacity

Defoliation creates a strong competition between the vegetative and reproductive organs. The vines must then draw from their reserves, that could effectively lead to a lower vigor and fertility in the long term. An intensive defoliation is, therefore, not recommended on vines that are either too young or have a low vigor. The long-term durability of the vines did not seem to be affected in the context of this study.

After veraison, defoliation is not generally recommended, exposing a risk of slowing the maturation of the grapes and increasing the berry sunburn symptoms. A late defoliation undertaken just before the harvest, presents the sole interest of gaining time during the harvest, estimated at 20-30% on the scale of the plot (CIVC 2019).

Before berry set: pre-floral defoliation or «early»

Pre-floral defoliation presents important consequences on the rate and level of the berry set. A defoliation that is effectuated very early (stage of separated flower buds) and intensively (100% of the bunch zone at the level of six leaves including the lateral shoots) such as realized in the context of these trials, systematically brings a yield reduction that can reach 40%, regardless of the vintage, the grape variety or the yield potential[3,4,5].

Even if the lower yield would contribute to limiting the green harvesting work, the pre-floral defoliation must be, therefore, applied in a reasoned and parsimonious manner so as to avoid excessive yield loss. That being said, the impact of defoliation on the yield can be easily adjusted by the intensity of the operation[5]. Furthermore, pre-floral defoliation presents the advantage of considerably reducing the risk of berry sunburn.

Defoliation at the moment of the bunch closure resulted in increased symptoms of berry sunburn, whereas the defoliated variant during the flowering period showed

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intermediary results. In short, the earlier the defoliation, lesser are the berry sunburn symptoms[6]. In fact, the bunches are exposed to sunlight in a period that is often cooler than in high summer. Furthermore, the bunch structure is significantly modified: fewer berries, with thicker skins[4,5] (figure 1), more resistant and richer in polyphenols with an antioxidant role.

Quality of the musts and the wines

The impact of defoliation on the composition of the grape must varied mostly depending on the grape variety. The maturity (sugars, acids) of the musts at harvest – above all determined by the weather conditions of the vintage – did not vary as a function of the defoliation period. Only the variant that was not defoliated emerged with a higher acidity in certain years (Pinot noir, Merlot)[6].

All the same, the pre-floral defoliation helped the accumulation of the polyphenols in the grape skin and thus improved the color and the stability of the red wines[4]. The Pinot noir wines were considerably improved through the practice of pre-floral defoliation: better bouquet, better structure on the palate, better overall impression. The Merlot wines were improved in certain years and the Gamay wines – a grape variety with greater plasticity – were minimally impacted. The quality and typicity of the white wines (Chasselas and Doral) were not modified, regardless of the defoliation period, most probably because the wines were vinified after the direct pressing without any skin contact maceration[3,5]. Pre-floral defoliation had no adverse effect on the wines.

Mechanical defoliation

The mechanization of defoliation is common practice and economically advantageous. The different techniques of mechanical defoliation are presented in a very comprehensive study (IFV 2009)[1]. The mechanization of pre-floral defoliation is feasible with the pneumatic-type leaf-thinner. The first results of the trials that have been undertaken since 2016 on Gamay and Doral grape varieties are interesting. Usually undertaken after the flowering period, the passage of the machine can, in fact, be realized before the flowering, once the lifting work has finished. The pre-floral mechanical defoliation induces a reduction in the yield – lower rate of berry-set and loss of flower buds – and seems to have the same impact on the quality of the must in comparison to a manual pre-floral defoliation.

Table 1. Defoliation periods and their consequences. Extreme negative effect (- -), negative (-), neutral (0), positive (+), very positive (+ +)[2]

Defoliation period	Healthy state	Yield	Time saving at harvest	Quality of musts and wines
Separated buds – berry set Stades BBCH: 57 → 71	+ +	- - / - As a function of defoliation intensity	+	- / + + Depending on grape variety and weather conditions
Berry set – Véraison Stades BBCH: 71 → 83	+ +	- / 0	+	- / +
After véraison Stades BBCH: 83 → 89	+	0	+	- / 0 The leaf-fruit relation must remain sufficient
Just before harvest Stade BBCH: 89	0	0	+ + Targeted Defoliation on the bunches	0

The pre-floral defoliation affects the structure of the berries.

The berry size is often smaller following a pre-floral defoliation. Furthermore, the thickness of the skin increases significantly. The resulting skin-pulp relationship has an impact on the composition of the musts at harvest.

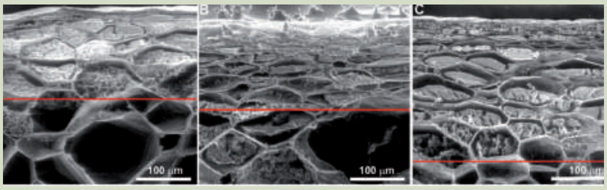

Figure 1. Cross sections of the Chasselas grape skins just before the harvest shows the effect of the defoliation period on grape skin thickness. The red line defines the limit between the skin cells (above) and the pulp cells (below). A: Non-defoliated variant; B: Classical defoliation at the bunch closure stage; C: Pre-floral defoliation at the separated flower bud stage. Trials on Chasselas, Pully 2015[5]. Images effectuated by an electronic microscope (Environmental scanning electron microscopy, ESEM).

Conclusion

Despite the variability of its impact – principally linked to the climate and the grape variety – the practice of defoliation before the veraison systematically produced positive results in the battle against fungal diseases on the vines and on the grape composition. This study, undertaken on five grape varieties in the regional context of Switzerland thus confirms the majority of the results obtained on other grape varieties and in different soil and weather conditions (table 1). If it is realized earlier, just after the berry set, it reduces the risk of berry sunburn. To the extent that a lower yield is sought, the pre-floral defoliation, when practiced in a reasoned manner, is a useful prophylactic practice for managing the yield, increasing the resistance to pathogens and improving the polyphenol content of the musts at harvest. ■

Thibaut Verdenal, Vivian Zufferey, Agnès Dienes-Nagy, Gilles Bourdin, Katia Gindro and Jean-Laurent Spring

Agroscope research station, avenue Rochettaz 21, 1009 Pully, Suisse

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Measuring the phenology to more effectively manage the vineyard

>>> Phenology is concerned with the periodic phenomenon of the vine growing cycle (bud burst, flowering, veraison (color change), in relation to the climate. It is a veritable biological clock of the vines. The timing of the numerous operations in the vineyard (phytosanitary protection, defoliation, crop thinning…) is undertaken in accordance with the phenological stages. Since the precociousness of the latter is directly linked to the temperature, the phenology is also a marker of global warming. <<<

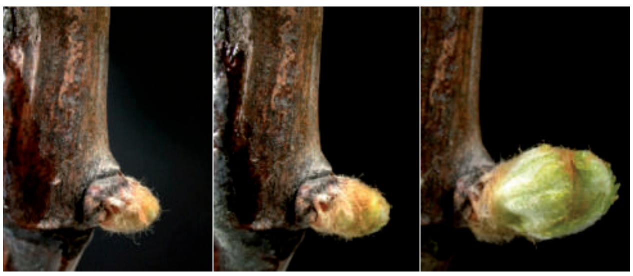
For vintners, consultants and researchers, it is important to closely follow the phenology of the vines with an appropriate and solid methodology. Within the framework of the Perpheclim project, a group of French researchers realized a technical sheet describing the protocol for observing the phenological stages. The harmonization of the methodology allows not only to possess more reliable data, but also to more easily compare the acquired observations in different sites by different observers.

The three principle vine growth stages observed are the budburst, the flowering and the veraison (color change). The adoption of a common language for all experimenters will permit the facilitation of exchanges and constitute a series of comparable data, particularly useful when exploring the consequences of climate change. Consequently, we propose in this technical sheet, evaluation methods of these three stages that were established by a work-group within the framework of the «Perpheclim du Métaprogramme ACCAF» project. We have decided to use the BBCH scale[1,2] so as to permit the comparison with other plant species, both annuals and perennials. We reference the correspondence with the defined stages as per Baggiolini (1952)[3].

Budburst and leaf emission/BBCH 07 - Stage C 50% of stage, small green or red tips

The budburst represents the starting point of the plant growth with the appearance of the first leaves. From this moment on, the plant will, once again, start its photosynthetic activity and shift progressively from a growth based on its reserves to a growth based on the production of newly synthesized carbohydrates.

- For notations, take into account only the vine-plants that are definitively established and in production.
- We recognize that a bud is in budburst if we see a small green or red tip.
- We consider only the principal buds.
- The retained stage corresponds to the date at which 50% budburst has been reached in relation to the number of productive buds left at the pruning.
- It is necessary to undertake the observations on at least five vine-plants per homogenous zone.
- Passage frequency: From the moment when a minimum of 5% of buds have burst, do at least one additional passage with a maximum of one-week interval, in a manner to have one observation after 50% of the buds have burst.
- The date of «50% budburst» is obtained by interpolation between the observed values before and after 50%.



BBCH 05 Woolly bud — BBCH 07 Visible green point — BBCH 07 Exceeded

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BBCH 60 - Beginning of flowering

BBCH 65 - 50% flowers open (detached caps)

BBCH 69 - End of flowering

■ Flowering/BBCH 65 - Stage I Stage 50% of flowers open

The flowering marks the beginning of the reproductive stage: the fall of the cap corresponds to the moment where the pollen will come into contact with the stigmas. The process of fertilization of the ovum that follows, conditions the formation of the berries and the pips, it thus constitutes a crucial moment in the development cycle.

➢ For notations, take into account only the vine-plants that are definitively established and in production.

➢ It is considered that a flower is open when the base of the cap is detached, regardless of whether it falls off or not. We estimate a level of flowers open. The retained stage corresponds to the date at which a level of 50% is reached.

➢ It is necessary to undertake the observations on at least five vine-plants per homogenous zone.

➢ To determine the stage of 50 % flowering, we evaluate the level of flowering per vine-plant or by inflorescence, then we calculate an average.

➢ Passage frequency: From the moment when we observe a minimum 5% of flowers open, do at least one supplementary passage with a maximum of one-week interval, in a manner to have one observation after 50% of the flowers have opened.

➢ The date of «50% of flowers open» is obtained by interpolation between the observed values before and after 50%.

■ Veraison (color change)/BBCH 85 Stage M Stage 50% of berries in veraison

The veraison (color change) marks the beginning of the ripening process of the grapes, that finishes at the harvest.

➢ For notations, take into account only the vine-plants that are definitively established and that are in production.

➢ We consider that a berry has completed its veraison if it is soft to the touch.

➢ This criterion permits an unbiased comparison of the grape varieties, whether white or red. Always undertake notations at the same hour, preferably in the morning.

➢ The retained stage corresponds to the moment at which the berries are soft to the touch.

➢ How to evaluate the level of berries after completed veraison? Two methods are possible:

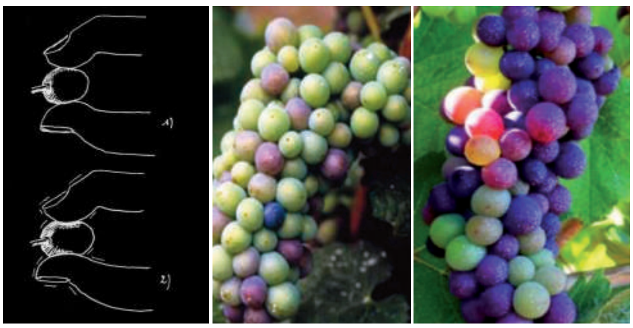
• By palpation of at least 100 berries on-site or in the laboratory (ex. 20 berries on 5 vine-plants). For certain varieties, it is, in fact, not possible to undertake one-time sampling of the berries since the bunches are too compact. It is therefore necessary to undertake the on-site evaluation without destructive sampling.

• The use of the color appearance method is acceptable for interannual comparisons of the same grape variety at the same site. In this case, a visual estimate of the percentage of colored berries on the entirety of the bunches of the vine-plant must be effectuated.

➢ It is necessary to undertake the observations on a minimum of five vine-plants per homogenous zone.

➢ Passage frequency: from the moment when we have observed a minimum of 5% of berries soft to the touch, do at least 1 supplementary passage with a maximum of one-week interval, in a manner to have one observation after 50% of the berries are soft to the touch.

➢ The date of «50% berry veraison completion» is obtained by interpolation between the observed values before and after 50%. ■



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Agnès Destrac-Irvine[1], Gérard Barbeau[2], Laure de Resseguier[1], Thierry Dufourcq[3], Vincent Dumasi[5], Inãki Garcia De Cortazar-Atauri[5], Hernan Ojeda[7], Nicolas Saurin[6], Cornelis van Leeuwen[1] and Éric Duchêne[4]

[1]UMR EGFV - Inra/université de Bordeaux/Bordeaux Sciences Agro - 33883 Villenave d'Ornon, France
[2]Unité Vigne & Vin - Inra - 42 rue Georges Morel, BP 60057, 49071 Beaucouzé Cedex, France
[3]Institut Français de la Vigne et du Vin Pôle Sud-Ouest Château de Mons, 32100 Caussens, France
[4]UMR SVQV - Inra/Université de Strasbourg 28 rue de Herrlisheim, BP20507, 68021 Colmar Cedex, France
[5]Unité de Service Agroclim - Inra, Domaine Saint Paul, Site Agroparc, CS 40 509, 84914 Avignon Cedex 9, France
[6]Unité Expérimentale de Pech Rouge - Inra - 11430 Gruissan, France
[7]Domaine de Vassal - Inra - 34340 Marseillan Plage, France

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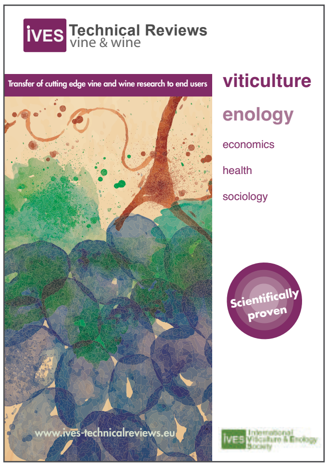

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