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A few words on grapevine winter buds and pruning in consideration of sap flow

Alain Deloire[1], Carole Dumont[2], Massimo Giudici[2], Suzy Rogiers[3], Anne Pellegrino[1]

1 University of Montpellier (L'institut Agro), France
2 Simonit & Sirch, Italy
3 NWGIC, Department of Primary Industries-NSW, Australia

One objective of pruning it to manage yield per vine (or per m²) and this is achieved by regulating the number of latent buds (i.e. buds which bear the primordia of inflorescences). For many year growers and wineries have been interested in what is currently called: gentle pruning, precision pruning, or pruning with respect to sap flow! But what is hiding behind these concepts?

This article aims to summarise some principles linked to what we could call "gentle pruning". We will detail i) pruning methods that limit or minimize pruning wound size/surface area on grapevine arms and spurs ii) and pruning that allows for a morphology that is conducive to continuous sap flow versus the 'hydraulic isolation' of regions within the vine.
Let's share to introduce the article a few words on grapevine dormancy and latent bud organisation.

A few words on grapevine dormancy

Grapevine dormancy is an important phenological period comprising of both endodormancy and ecodormancy. Endodormancy is the inhibition of growth originating from the latent bud meristem. It is brought about by internal factors within the plant, which prevent the breakage of dormancy even if external factors are optimal for growth. Aside from hormonal regulation, endodormancy is triggered by shorter days and cooler temperatures. Winter chilling is then necessary to overcome endodormancy. Although the effect of chilling temperature on dormancy release needs further research at the molecular level, a 200 hour-period (eight days) with a mean daily temperature ≤ +8°C proved to be efficient to permit the buds to break within a reasonable duration and to an acceptable level.
When endodormancy has been overcome, grapevine varieties are physiologically ready for bud break, however conditions that lead to ecodormancy must now also be surpassed. Vines can exist within an ecodormant state if environmental factors that support root activity and bud growth are not optimal. These main environmental factors permitting budbreak include warm temperature (air and soil; > +15 °C) and soil water refilling[1].

A few words on the latent buds in grapevines

The latent bud is a compound of vegetative miniaturised axils protected by scales[2]. The principal axil of this compound is called the latent primary axil, which will develop into the future primary shoot (year n+1). The budbreak of the latent buds at each node of the primary shoot (year n) is first inhibited by the hormonal release from the primary shoot and the prompt bud which form the shoots called laterals.
This nascent structure in the latent bud differentiates over 2 to 4 months simultaneous to the growth of the bearer shoot before entering into endodormancy (around August in the Northern Hemisphere). Its phyllotaxic plane is perpendicular to that of the prompt bud and consequently the new developed shoot (year n+1) will grow in a parallel plan to that of the bearer shoot/cane.
The meristem which initiated the primordia of leaves and inflorescences in latent buds (year n) pursues its development after budbreak (year n+1). The developing shoot is named the proleptic axil. The potential fertility



FIGURE 1. Example of pruning wounds which have been positioned over years on the same side of the arms and the associated spurs (yellow arrows). This promotes the anatomical isolation of the pruned organs while maintaining the hydraulic integration across the plant.

represents the number of incipient inflorescences developed on the primary shoot (on average 1 to 3 primordia of inflorescences per latent bud), which will form the future grapes. This fertility depends on the cultivar, rootstocks and on the climate (mainly temperature, light and water) and trophic conditions of the year in which the bud is formed.
The main bud primordium of the latent bud, which is a complex of three bud primordia, bears 70-80% of the potential yield.

While pruning, some basic principles need to be considered for grapevine sustainability

Gentle pruning was known and practiced in French vineyards as early as the early 20th century (as published by Lafon R., 1921[3]). Strangely, these practices were forgotten for decades but have been reintroduced and practised worldwide in vineyards for the past 20 years. Let's share some information about gentle pruning in this article; here we present a synthesis of some books, published research articles and personal results from the authors.
Pruning is a traumatic cultural practice for vines irrespective of the pruning method (hand or mechanical pruning). In this regard, it is important to distinguish two founding principles which are not always dependant on each other: i) to reduce the size of the pruning wounds (to be adapted and reasoned according to the situation); ii) to respect the hydraulic flow between the vine organs (trunks, arms, spurs).
Let's mention a few rules of gentle pruning:
1. As published by Lafon R. (1921) it is crucial to respect the sap flows by positioning the pruning wounds, when possible, on the same side of the arms and spurs (figure 1).

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2. In the case of cane/Guyot pruning[4, 5], to avoid the formation of a willow head.
3. To prevent the creation of dead zones (desiccated cones) within the perennial organs (trunk, arms, spurs…) by avoiding cuts in close proximity to the wood (figures 2, 3).

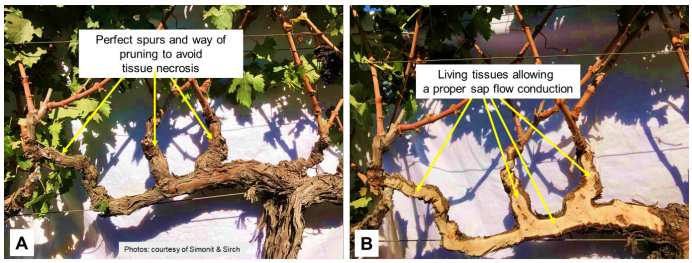


FIGURE 2. Example of proper spur (cordon) pruning respecting the sap flow of the arm and the spurs. (A) Applying gentle pruning will lead to the increase in the size of the spurs year after year; (B) Gentle pruning does not induce necrotic tissue formation in the arm and spurs.

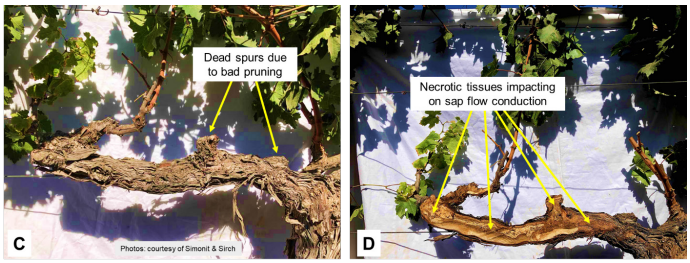


FIGURE 3. Example of inappropriate spur pruning on a cordon that has resulted in tissue necrosis of the arm and the spurs, interrupting the conduit for sap flow. (C) Necrotic/dead spurs on a cordon due to inappropriate/bad pruning; (D) Inappropriate pruning has induced wood/tissue necrosis at the spur and arm levels, impacting on sap flow and on vine sustainability.

4. Therefore, in wood older than 1 year, a portion of wood should be left while pruning. The length should be 1,5 or 2 times the diameter of the pruned organ, as presented in figure 4[6].



FIGURE 4. (A, B) Examples of inappropriate pruning cuts which have been made too close to the adjoining wood (conducting tissues) (orange arrows). (C) A portion of internode should be left while pruning (the length should be 1,5 or 2 times the diameter of the pruned organ; yellow arrows).

5. The consequence of leaving a portion of the wood, however, could be the development of the basal buds which will require some extra work by cleaning/removing these growing shoots in spring.
6. The role of the diaphragm (figure 5) of the cane is to protect the node and the associated latent bud from necrosis or bio-aggressor infection as a result of pruning. It acts by isolating the pith between successive internodes[7].
7. To protect the latent bud from damage due to the pruning wounds located above it, it is recommended to leave a section of internode long enough (at least 2 cm) above the chosen latent bud which bears the future crop (figure 6). In certain wine regions (Champagne, Charentes, Argentina Atlantic coast…), the length of the necrosis can be more extensive and is also dependent on the variety. For these situations, one solution is to retain the full internode above the latent bud.
8. Irrespective of the training system it is crucial to allow for the continuous development of living wood (which means to avoid the formation of dead wood) which will lead to an increase in the diameter of the arms and the spurs (figure 2).
The general aims of gentle pruning respecting the sap flow are:
i) to avoid the gradual yearly build-up of necrotic-dead wood/tissues,
ii) to maintain the vascular system (xylem-phloem) operational.

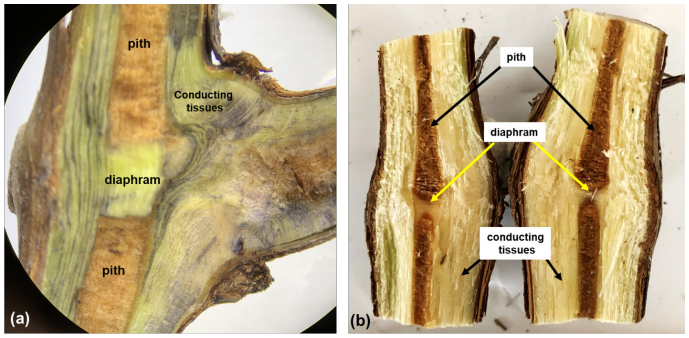


FIGURE 5. The diaphragm is located at the node level and is present in a one-year cane (a) and three-year stem (b). Photo (a) is showing starch colored in violet by the Lugol and located in the parenchyma cells of the xylem II.

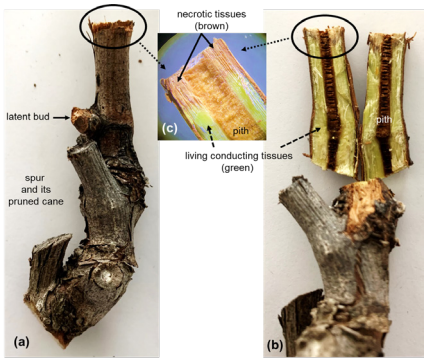


FIGURE 6. The wound created while pruning a winter cane (a) will lead to the necrosis of the conducting tissues just below the wound. The length of the necrotic region does not exceed 0,5 to 1 cm under certain climatic conditions. (b, c) show the dead tissues (brown zone) in comparison with the living conducting tissues (xylem, phloem) around 10 weeks after pruning (Shiraz).

Why apply gentle pruning?

Avoiding tissue necrosis due to pruning wounds, and therefore respecting the vine's hydraulic integration[8], will improve vine and vineyard sustainability and will help:
a) To achieve more homogeneous budbreak and primary shoot development, and therefore homogeneous vines, considering that proper sap flow pathways are needed for shoot development.
b) To achieve a better fruit zone microclimate (depending on the vegetative expression/vigour of the vines) by increasing the height of the spurs over years on a cordon.
c) To avoid the spread of wood diseases (Esca, *Botryosphaeria* dieback…), another goal of gentle pruning (taille "non mutilante")[9]. ■

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