Vitis 60,137–141 (2021) DOI: 10.5073/vitis.2021.60.137-141

Pruning cuts affect wood necrosis but not the percentage of budburst or shoot development on spur pruned vines for different grapevine varieties

P. Faúndez-López[1], J. Delorenzo-Arancibia[1], G. Gutiérrez-Gamboa[2] and Y. Moreno-Simunovic[1]

[1] Centro Tecnológico de la Vid y el Vino, Facultad de Ciencias Agrarias, Universidad de Talca, Talca, Chile
[2] Escuela de Agronomía, Facultad de Ciencias, Universidad Mayor, Huechuraba, Chile

Summary

Two experimental studies were performed in this trial. In the first, the aim was to quantify wood necrosis generated by pruning cuts on aboveground permanent (arms and trunks) and non-permanent (spurs) woody structures of 'Cabernet Sauvignon' vines. In the second, the goal was to evaluate the effect of cutting distance from the basal end of the shoot in spur pruned vines on budburst and further shoot development for 'Grenache', 'Cabernet Franc' and 'Malbec' varieties. Based upon the first experiment, the area and depth of wood necrosis was highly influenced by the distance where the pruning cut was performed over the node. Furthermore, the diameter of the spur that was cut was not significantly related to either the area or the depth of the necrotic wood generated after the cut. Aboveground vine wood necrotic area ranged from 9 to 44 % of the total wood area measured in 'Cabernet Sauvignon' cordon trained spur pruned 25-year-old grapevines. For each vine a larger proportion of the necrotic wood (20 to 46 % of necrotic area) was present in the arms when compared to the trunks (1 to 28 % of necrotic area). As a result of the second experiment, spur budburst and further shoot development was not affected by the distance from the node where the pruning cut was performed for any of the cultivars considered in the study contrary to what is commonly believed.

K e y w o r d s : diaphragm; node; pruning cuts; pruning wounds; spur pruning; vascular system.

Introduction

Pruning was a well-established vineyard management practice, long before the scientific method was created, even close to the initiation of the Christian era (Winkler *et al.* 1974). The main goals of this practice are to maintain grapevine form, regulate the number and position of shoots on a vine, improve fruit quality, improve bud fruitfulness and stabilize grapevine yield over time (Deloire 2012). In general terms pruning practice has not changed much in time as it has been considered an art as much as a technique. According to Winkler *et al.* (1974) early in the last century Vergil and Pliny general pruning instructions were still widely practiced, with the exception of small empirical changes, such as the length and position of spurs, which were introduced in the 19th century by Jules Guyot.

Grapevine pruning requires lignified shoots or permanent wood to be cut, which inevitably results in a wound of greater or smaller area, according to the size of the removed structure (Dal *et al.* 2008, Dal 2013, Simonit 2018). During the growing season and after a pruning cut tyloses develop quickly and close to the wound in the xylem of current-year shoots of the grapevine allowing for the occlusion of up to 85 % of the vessels (Sun *et al.* 2006). On the contrary, during the wintertime the vine has the capacity to produce a gummy sap that partially obturates the conductive vessels of the plant (Keller 2020) leaving many of them exposed to the air for a long period of time. Furthermore, larger pruning cuts in older wood (more than 2-year-old) may result in the exposure of the vascular system to the environment, leading to a natural dehydration and death of the cells adjacent to the cutting zones. This generates larger dead areas known as desiccation cones that partially seal the injury and act as a physical barrier between the grapevine vascular system and the environment, but that are colonized by several fungi species (Maher *et al.* 2012, Travadon *et al.* 2016, Cholet *et al.* 2021). The presence of this necrotic wood in permanent parts of the grapevine can translate into potentially harmful effects for them, such as the partial obstruction of the vascular system (Rolshausen *et al.* 2010, Pouzoulet *et al.* 2019). The negative effects of a desiccation cone may depend on the diameter of the removed structure, its location in the plant, the proximity in which the pruning cuts are made into lignified shoots and the age of the removed wood structure during pruning (Simonit and Sirch 2013).

This report was aimed to quantify wood necrosis generated by pruning cut wounds on 'Cabernet Sauvignon' spur pruned cordon trained grapevines and to determine the effect of cutting distance from the basal end of the shoot in spur pruned grapevines on budburst and shoot development for 'Grenache', 'Cabernet franc' and 'Malbec' cultivars.

Correspondence to: Dr. Y. Moreno-Simunovic, Centro Tecnológico de la Vid y el Vino, Facultad de Ciencias Agrarias, Universidad de Talca, Av. Lircay S/N, Talca, Chile. E-mail: ymoreno@utalca.cl and to Dr. G. Gutiérrez-Gamboa, Escuela de Agronomía, Facultad de Ciencias, Universidad Mayor, Camino La Pirámide N°5750, Huechuraba, Chile. E-mail: gaston.gutierrez@umayor.cl

Material and Methods

A first experiment was carried out using spur pruned cordon trained 'Cabernet Sauvignon' grapevines that were randomly selected from a twenty-five-year-old vineyard during the wintertime and subsequently uprooted from the ground using a backhoe. Nine samples of three vines each were randomly chosen and fully dissected on a carpenter's bench using a reciprocating saw (Makita, JR3070CT 1510w), getting all the spurs of one year (non-permanent structures), the arms of more than two years and the trunks (permanent structures). Longitudinal cuts were made in order to quantify the percentage of necrosis in permanent and non-permanent structures with respect to their corresponding living wood area (Fig. 1). Then, images of the partial and complete anatomy of the cuts were taken with a professional camera (Canon, PowerShot A2200). Each image was analyzed through "ImageJ" software package according to the procedure reported by Abramoff *et al.* (2004) and shown in Fig. 1. In brief, ImageJ quantifies the number of pixels in a given area and as a consequence, the relative area of each pixel through a reference of indicated length. This allowed us to determine the percentage of necrosed wood in non-permanent and permanent wood structures of each grapevine. Based on this, spur diameter (cm), necrosis depth (cm), area of necrotic wood (cm^2), the distance of the pruning cut from the node (cm) and the distance of the necrosis edge from the pruning cut to the node (cm) were measured in non-permanent structures (Figs 1a to 1e). In addition, total wood area (cm^2) and necrotic area (cm^2) were measured for arms, trunks, and aboveground vine wood grapevine. Linear regression analysis was used to identify the existence of relationships among the measured variables and their degree of correlation using Statgraphics Centurion XVI.I (Warrento, Virginia, United States).

For the second experiment a 12 year old experimental vineyard with cordon trained spur pruned vines of Grenache, Cabernet franc and Malbec was selected. Four treatments consisting of cutting the renewal spur at different internodal positions (as shown in Fig. 2) were randomly arranged within the vineyard, taking complete rows (30 grapevines) per treatment in the 2017-2018 season. At the following spring, a visual scoring of retained buds regarding their budburst

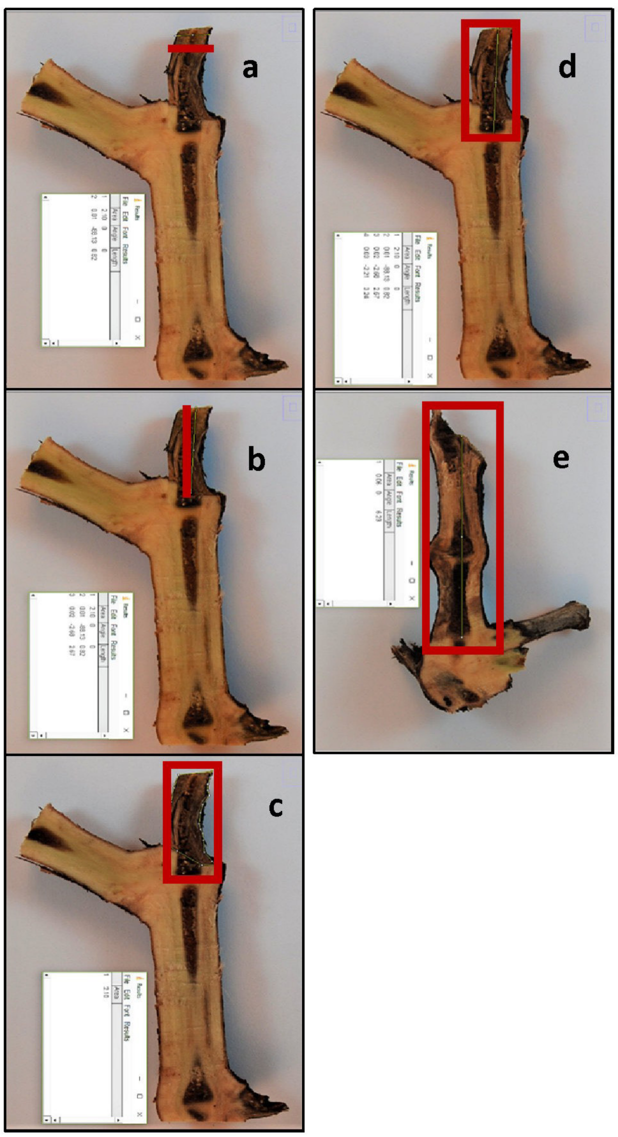

Fig. 1: Measurement of total wood and necrotic wood area of spurs coming from cordon trained spur pruned twenty-five year old 'Cabernet Sauvignon' grapevines using ImageJ (Abramoff *et al.* 2004). Measurements of (**a**) spur diameter (cm), (**b**) necrosis depth (cm), (**c**) area of necrotic wood (cm^2), (**d**) the distance of the pruning cut from the node (cm) and (**e**) the distance of the necrosis edge from the pruning cut to the node (cm).

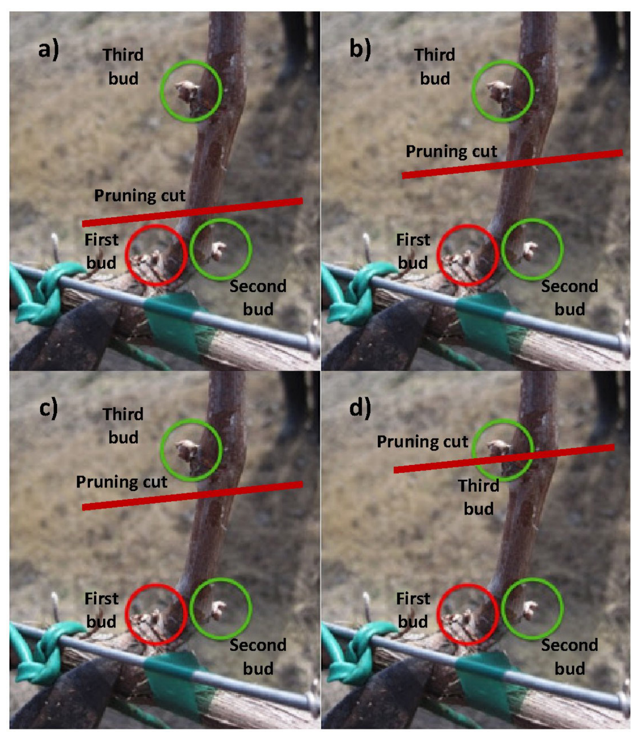

Fig. 2: Detail of pruning treatment cuts applied to cordon trained spur pruned vines of 'Grenache', 'Cabernet Franc' and 'Malbec' cultivars. Pruning cuts made: **a**) above the diaphragm of the retained second bud (treatment 1), **b**) in the internode halfway between the second and third bud as counted from the base (treatment 2), **c**) under the diaphragm of the third bud (treatment 3), and **d**) above the diaphragm of the retained third bud (treatment 4).

Fig. 3: Budburst scoring categories according to subsequent shoot development. **a**) Full budburst: both retained buds burst and fully developed. **b**) Partial budburst: both retained buds burst but only the first (not the distal) reached adequate shoot development. **c**) No budburst: only the first bud burst and developed but the distal bud was not able to burst or develop.

and shoot development was classed into one of the following 3 categories: 1) full budburst; 2) partial budburst and 3) no budburst as described in Fig. 3. Statistical analysis was performed using a Kruskal-Wallis test rank (no-parametric data) by Statgraphics Centurion XVI.I (Virginia, USA). Differences between samples were compared using the LSD test at 95 % probability level.

Results and Discussion

The area and depth of necrotic wood in non-permanent structures was not related to the diameter of the pruning wound (Fig. 4). In addition, a strong relationship was found between the area and depth of necrotic wood and the presence of a node in these structures (Fig. 4). Hidalgo (1991) explained that wood necrosis begins with the dehydration of the cells involved in the wound and continues with the necrosis of the adjacent tissue, due to its lack of functionality. Furthermore, pruning cuts made too close to the main trunk or cordon (an aspect not measured in our experiments), could favour rapid development of dry necrotizing wood under the wound surface from the tissues exposed to the open air as pointed out by Grosclaude (1993). This could indicate diaphragm participation on limiting the advance of necrotic tissue since according to our results, the distance of the pruning cut over the node where necrosis ended determined the area and depth of necrotic wood. Besides, resistance to necrosis penetration can be offered by living tissues, which react by depositing polyphenols and other substances around the wound, and/or producing a callus able to seal the injury (Grünwald *et al.* 2002). Hidalgo (1991) mentioned that the diaphragm has a direct participation in the limitation of

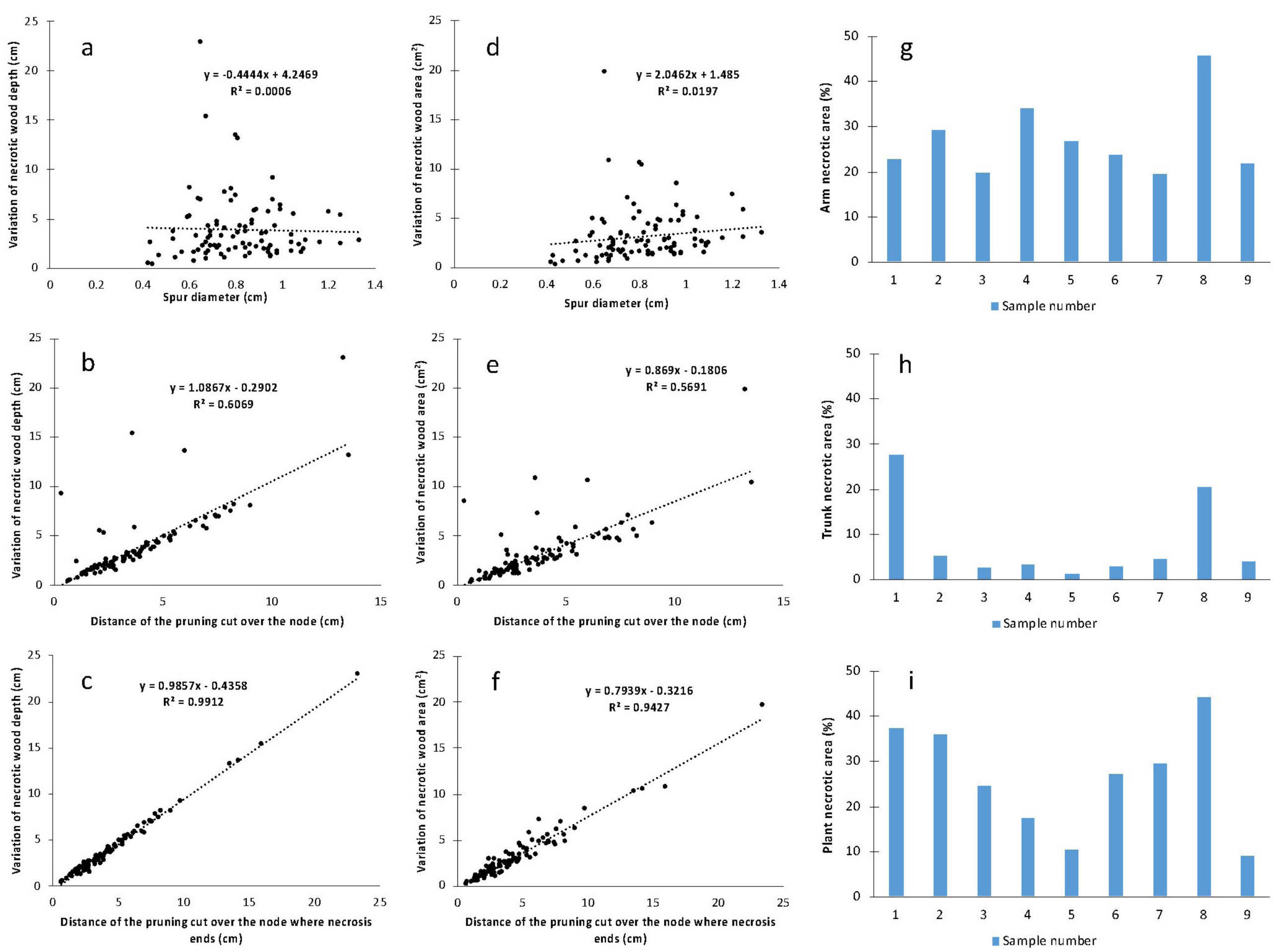

Fig. 4: Variation of necrotic wood depth according to **a**) spur diameter (r^2:0.00), **b**) distance of the pruning cut over the node (r^2:0.61) and **c**) distance of the pruning cut over the node where necrosis ends (r^2:0.99), and variation of the necrotic wood area according to **d**) spur diameter (r^2: 0.02), **e**) distance of the pruning cut over the node (^{r2}: 0.57) and **f**) distance of the pruning cut over the node where necrosis ends (r^2: 0.94). Percentage (%) of necrotic wood found in **g**) arms, **h**) trunk and **i**) total aboveground vine wood.

dehydration after a pruning cut is made. This characteristic could be due to the structure of the diaphragm, which is made up of hard, thickened pith cells with sclerified cell walls (Keller 2020); and its specific position within the node, which is in an intermediate zone, achieving a segmentation between the organs. This structure may be part of a natural defense mechanism against wounding, or a defense mechanism triggered by pruning, allowing the grapevine to reduce the potential damage made by cuts. Furthermore, Lafon (1921) and Simonit (2016) have stressed the importance of performing pruning cuts only on non-permanent wood structures (one year old wood) in order to maintain healthy sap flow on the vines avoiding the formation of multiple desiccation cones of dead wood. This could be due to the fact that these structures contain nodes and diaphragms which limit wood necrosis towards the permanent structures of the grapevines such as arms, canes or trunk.

A high percentage and variability of necrosed wood was found in arms when compared to trunks (Fig. 4), probably due to the greater number of cuts are that are regularly made in vine cordons in comparison to those performed in trunks. These results are coincident with those of Lecomte *et al.* (2018) who suggested that the amount of dead and dry wood caused by training and pruning methods is relevant for grapevine decline. Our results support the recommendation of Simonit and Sirch (2013), who reported that the best way to renovate a fruiting center or spur is to perform the pruning cut over the basal bud with the aim of preventing wood necrosis in the permanent wood structure, thus allowing for a continuous sap flow into the new shoot during the growing season.

According to the results of the second experiment, in 'Grenache', 'Cabernet Franc' and 'Malbec' grapevines, the buds tended to burst and develop in a high percentage (> 70 %) (Fig. 5), regardless of the distance above the node the pruning cut was made. Also, there were no statistical differences among the treatments, independent of the variety chosen for study. In this sense, our results do not match those of Hidalgo (1991), who stated that the pruning distance should be at least 2 to 3 cm above the node to avoid necrosis development into permanent wood structures.

Conclusions

Wood necrosis produced from a pruning wound in non-permanent structures of 'Cabernet Sauvignon' grapevines had a strong relationship to the distance in which the pruning cut was performed over the node compared to the diameter of the removed structure. Based upon these findings, as mentioned by different authors in specialized books, we could probably confirm the participation of the diaphragm in the necrotic limitation of tissue after pruning cuts. Grapevine arms presented a higher percentage and variability of wood necrosis than trunks. Based on the second study, regardless of the distance where the pruning cut is performed over the node in the shoot, budburst percentage and shoot development were not affected in 'Grenache', 'Cabernet Franc' and 'Malbec' grapevines. From a practical perspective and based on our results it seems reasonable to recommend limiting the generation of necrotic wood (desiccation cones) by avoiding pruning cuts made too close to permanent wood structures (cordons). That is desisting to cut any wood older than two years in order to avoid deep wood desiccation areas. This may reduce the area of exposed wounds, and in turn the risk of wood disease.

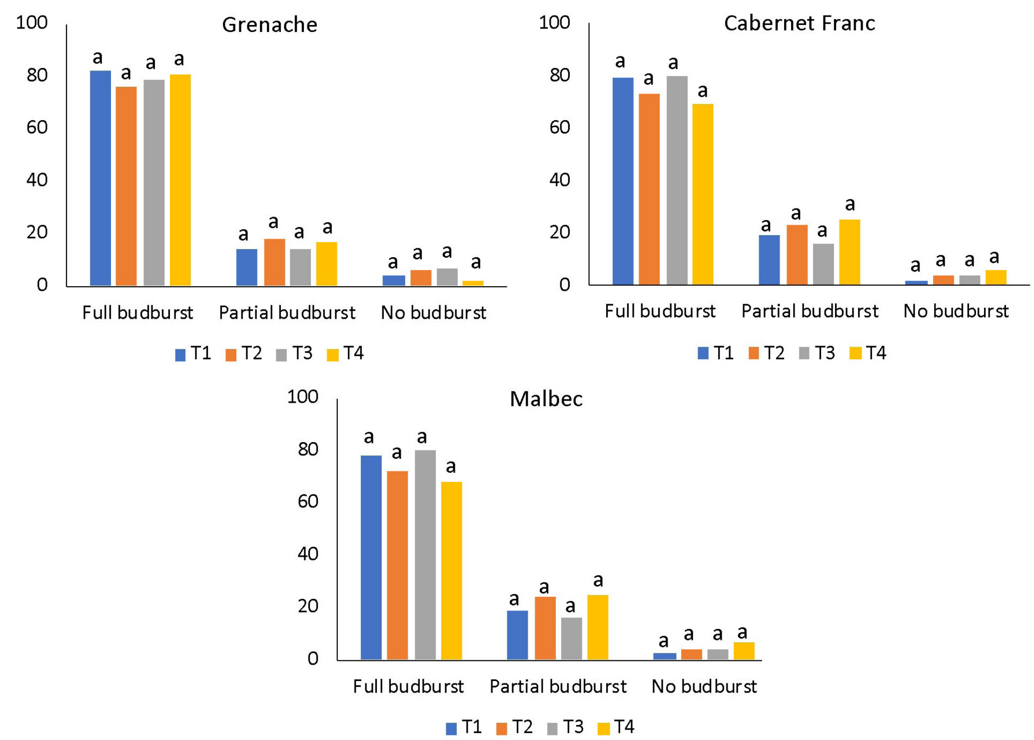

Fig. 5: Effect of cutting distance from the basal end of the shoot in spur pruned grapevines on budburst and shoot development for 'Grenache', 'Cabernet Franc' and 'Malbec' cultivars according to three categories of budburst scoring (Full, Partial or No budburst). Different letters within the graph represent significant differences (LSD test, $p < 0.05$).

References

Abràmoff, M. D.; Magalhaes, P. J.; Ram, S. J.; 2004: Image Processing with ImageJ. Biophoton. Int. **11**, 36-42.

Cholet, C.; Bruez, É.; Lecomte, P.; Barsacq, A.; Martignon, T.; Giudici, M.; Simonit, M.; Dubourdieu, D.; Gény, L.; 2021: Plant resilience and physiological modifications induced by curettage of Esca-diseased grapevines. OENO One, **55**, 153-169. DOI: https://doi.org/10.20870/oeno-one.2021.55.1.4478

Dal, F.; Bricaud E.; Chagnon L.; Daulny B.; 2008: Relationship between quality of pruning and decay of vines. Example of esca. Prog. Agric. Vitic. **125**, 602-608.

Dal, F.; 2013: Manuel des Pratiques Agricoles contre les Maladies du Bois. Réalisation SICAVAC et BIVC. Imprimerie Paquereau, Angers.

Deloire, A.; 2012: A few thoughts on grapevine training systems. Wine-Land **6**, 82-86.

Grosclaude, C.; 1993: Pathological study of exposed wood wounds in woody plants. Agronomie **13**, 441-456.

Grünwald, C.; Stobbe, H.; Schmitt, U.; 2002: Developmental stages of callus formation on wound edges of broad-leaved trees. Forstwiss. Centralbl. **121**, 50-58. DOI: https://doi.org/10.1046/j.1439-0337.2002.00050.x

Hidalgo, L.; 1991: Vine Pruning (4th ed). Ediciones Mundi-Prensa, Madrid, Spain.

Keller, M.; 2020: The Science of Grapevines: Anatomy and Physiology. (3th ed). Elsevier Inc, Oxford, UK.

Lecomte, P.; Diarra, B.; Carbonneau,A.; Rey, P.; Chevrier, C.; 2018: Esca of grapevine and training practices in France: results of a 10-year survey. Phytopathol. Mediterr. **57**, 472-487.

Lafon, R.; 1921: L'apoplexie: traitement préventif (Méthode Poussard), traitement curatif. Modifications à Apporter à la Taille de la Vigne dans les Charentes: taille Guyot-Poussard Mixte et Double. Imprimerie Roumégous et Déhan, Montpellier, France.

Maher, N.; Piot, J.; Bastien, S.; Vallance, J.; Rey, P.; Guérin-Dubrana, L.; 2012: Wood necrosis in Esca-affected vines: Types, relationships and possible links with foliar symptom expression. OENO One **46**, 15-27. DOI: https://doi.org/10.20870/oeno-one.2012.46.1.1507

Pouzoulet, J.; Scudiero, E.; Schiavon, M.; Santiago, L. S.; Rolshausen, P. E.; 2019: Modeling of xylem vessel occlusion in grapevine. Tree Physiol. **39**, 1438-1445. DOI: https://doi.org/10.1093/treephys/tpz036

Rolshausen, P. E.; Úrbez-Torres, J. R.; Rooney-Latham, S.; Eskalen, A.; Smith, R. J.; Douglas Gubler, W.; 2010: Evaluation of pruning wound susceptibility and protection against fungi associated with grapevine trunk diseases. Am. J. Enol. Vitic. **61**, 113-119.

Simonit, M., 2016: Guide Pratique de la Taille Guyot. Collection Vigne et Vin. France Agricole Ed., Paris, France.

Simonit, M.; 2018: Guide pratique de la taille cordon. Prévenir les maladies du bois. France Agricole Ed., Paris, France.

Simonit, M.; Sirch, P.; 2013: Il Metodo Simonit & Sirch Preparatori d'Uva. Scuola Italiana Di Potatura Della Vite, Venecia, Italy.

Sun, Q.; Rost, T.; Matthews, M.; 2006: Pruning-induced tylose development in stems of current-year shoots of *Vitis vinifera* (Vitaceae) Am. J. Bot. **93**, 1567-1576.

Travadon, R.; Lecomte, P.; Diarra, B.; Lawrence, D. P.; Renault, D.; Ojeda, H.; Rey, P.; Baumgartner, K.; 2016: Grapevine pruning systems and cultivars influence the diversity of wood-colonizing fungi. Fungal Ecol. **24**, 82-93. DOI: https://doi.org/10.1016/j.funeco.2016.09.003

Winkler, A. J; Cook, J. A.; Kliewer, W. M.; Lider, L. A.; Cerruti, L.; 1974: General viticulture. Second edition. University of California Press, Berkeley and Los Angeles, California.

Received October 10, 2020
Accepted April 23, 2021