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The role of diaphragm as a natural resistance to the necrosis produced by pruning cuts

Sourced from the research article "Pruning cuts affect wood necrosis but not the percentage of budburst or shoot development on spur pruned vines for different grapevine varieties" (Vitis, 2021)[1].

>>> Long before the scientific method was created, vine pruning was established as an art as early as at the beginning of the Christian era. Pruning is a way of reducing the vegetative part of the vine in order to limit its natural growth, and thus improve yield and grape quality by controlling the number of latent buds that are left per vine. Today, Virgilio and Plineo instructions are still being followed for pruning, with the exception of some small empirical changes, which were introduced in the 19th century by Jules Guyot. This report aims to evaluate the effect of pruning cuts on wood necrosis behaviour, and to determine the effect of pruning on shoot development on different vine varieties. <<<

Pruning and plant physiology

Pruning requires cuts to be made to the woody structures of vines, which will inevitably result in a wound of varying size, depending on that of the removed structure. Vines are able to produce a gummy sap substance and form tylose that obturate the conductive vessels of the vine in response to wounding or damage. Pruning cuts result in the exposure of the vascular system to the environment, leading to natural dehydration and the death of the cells adjacent to the cut zones; desiccation cones are then generated by the vine which seal the injury and act a protective barrier between the vine vascular system and the environment. This phenomenon results in the production of necrotic wood near the pruning cuts, leading to potentially harmful effects for the vines, such as the partial obstruction of the vascular system. These negative effects will 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.

Materials and methods

A first experiment was carried out on spur-pruned Cabernet Sauvignon vines that were randomly selected from a replanting vineyard, and subsequently uprooted from the ground using a backhoe. The chosen vines were dissected on a carpenter's bench using a reciprocating saw in order to obtain one-year-old spurs (non-permanent structures), arms more than two-years-old, trunks and whole vine (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 (Figure 1). Next, pictures of the partial and complete anatomy of the cuts were taken with a professional camera. Each picture was analysed through "ImageJ", which is designed for the scientific analysis of multidimensional images as shown in Figure 1. 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 necrosis wood in non-permanent and permanent wood structures of vines. Spur diameter[a] (cm), necrosis depth[b] (cm), area of necrotic wood[c] (cm^2), the distance of the pruning cut from the node[d] (cm) and the distance the necrosis edge travelled from the pruning cut to the node[e] (cm) were measured in non-permanent structures (Figure 1). Total area (cm^2) and necrotic area (cm^2) were measured for arms[f], trunks[g] and whole vine[h] (Figure 1). Linear regression analysis was used to identify the existence of relationships among the measured variables and their degree of correlation.

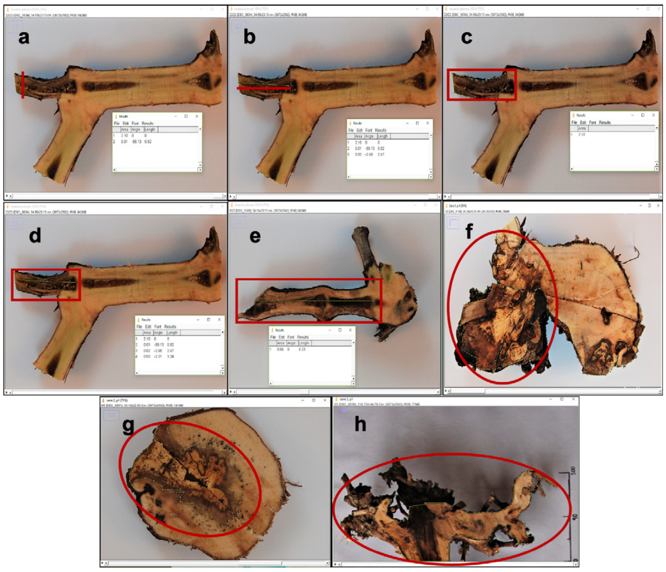

Figure 1. Study of necrosis in non-permanent structures[a-e], arms[f], trunk[g] and whole vine[h], using ImageJ.

A second experiment was performed on Grenache, Cabernet Franc and Malbec vines that were selected to evaluate the effect of different distances of cutting from the basal end of the shoot by spur pruning on shoot development. Four treatments were arranged randomly within the vineyard, taking a complete row per treatment. The treatments consisted of pruning the spurs in different internodal positions as shown in Figure 2. Visual scoring of the shoot growth the following season was classified according to one of three categories: 1) completely developed, 2) partially developed, and 3) not at all developed. The 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.

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Results and discussion

➔First experiment

The necrotic wood area in non-permanent structures was found to be unrelated to the diameter of the pruning wound (Figure 3). In addition, a strong relationship was found between the necrotic wood area and the presence of a node in these structures (Figure 3). Hidalgo (1991)[2] explained that 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. This could demonstrate the participation of the diaphragm in the necrotic limitation. Thus, 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.

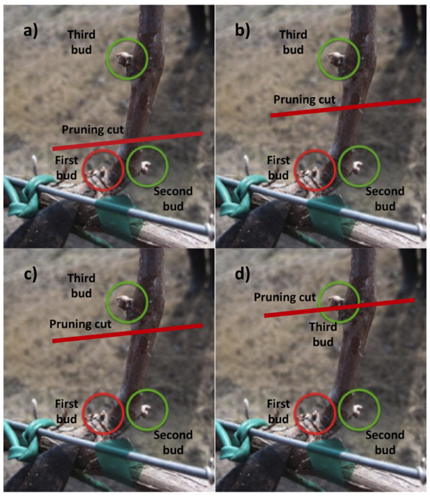

Figure 2. Treatments performed in the second experiment. The treatments consisted of increasing cutting distances from the basal end of the shoot to form spurs producing increasing lengths of tissue above the diaphragm at the node. a) Pruning above the diaphragm of the retained second bud. b) Pruning in the internode halfway between the second and third bud as counted from the base. c) Pruning under the diaphragm of the third bud. d) Pruning above the diaphragm of the retained third bud.

Hidalgo (1991)[2] and Aliquó *et al.* (2010)[3] mentioned that the diaphragm directly participates limiting of dehydration after the 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[4], as well as 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 vine to reduce the damage caused by cuts. Simonit and Sirch (2013)[5] pointed out the importance of performing pruning cuts only on non-permanent wood structures; this could be due to the fact that these structures contain nodes and diaphragms which limit wood necrosis in the permanent structures of the vines such as arms, canes or trunk.

A high percentage and variability of necrosis was found mainly in arms compared to trunks (Figure 3), probably due to the fact that in the arms a greater number of cuts are made in comparison to those performed in trunks. Our results support the recommendation of Simonit and Sirch (2013)[5], who reported that the best way to remove a shoot or spur is to perform the pruning cuts over the basal bud to avoid the necrosis penetrating the permanent wood structures on which the removed structure was supported.

➔Second experiment

According to our results, in Grenache, Cabernet Franc and Malbec vines a high percentage (> 70 %) (data not shown) of the buds tend to develop after pruning, regardless of the distance above the node of the pruning cut. Furthermore, there were no statistical differences between the treatments, regardless of the cultivar. In this respect, our results do not match those of Hidalgo (1991)[2] and Aliquó *et al.* (2010)[3], who stated that the pruning distance should be at least 2 to 3 cm above the node to avoid the necrosis penetrating the permanent wood structures.

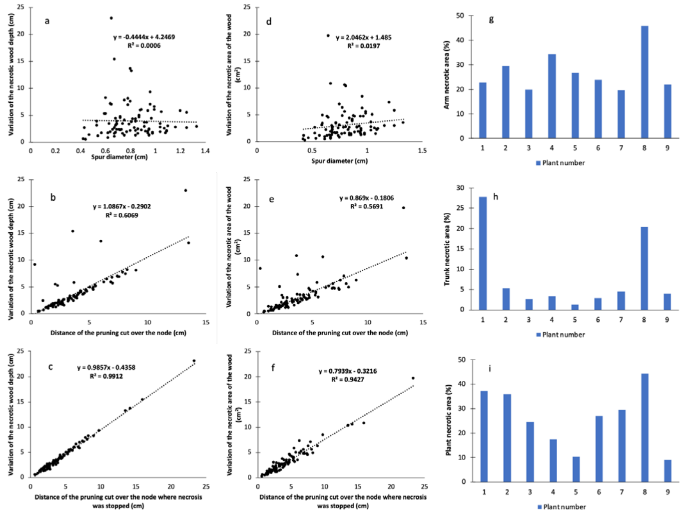

Figure 3. Variation of the necrotic wood depth depending on a) spur diameter (r^2:0.00), b) distance of the pruning cut over the node (r^2:0.61) and c) distance of the pruning cut over the node where necrosis was stopped (r^2:0.99), together with the variation of the necrotic area of the wood, depending on d) spur diameter (r^2:0.02), e) distance of the pruning cut over the node (r^2:0.57), and f) distance of the pruning cut over the node where necrosis was stopped (r^2:0.94). Percentage (%) of necrotic wood found in g) arms, h) trunks and i) whole vine.

Conclusion

The necrosis produced from a pruning wound in non-permanent structures of Cabernet Sauvignon vines had a strong relationship with the presence of a node. The arms showed a higher percentage and variability of wood necrosis than the trunks. Regardless of where the pruning cut was performed, the shoot development percentage was not affected in Grenache, Cabernet Franc and Malbec vines. Therefore, it is possible that the diaphragm may produce an effective natural resistance to the necrosis produced by pruning cuts. ■

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