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SHORT COMMUNICATION

Importance of quality maintenance pruning for young Ugni Blanc grapevines

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ABSTRACT

This article investigates and models the effects of maintenance pruning quality on the initial formation of desiccation cones and wood necrotisation. Two different types of pruning, short and long pruning cuts, were performed annually for three years in two Charente vineyards. The short pruning type removed the diaphragm. In the long one, four modalities were applied: these ranged from keeping a 1 cm chicot above the diaphragm, to leaving a much longer one to preserve the bud. Neither of the trials, whether for short or long pruning, showed any correlation between necrosis length and spur diameter ($R2 < 0.14$ for both trials). Charente Ugni Blanc necrosis length, for long pruning, proved significantly more extensive 8 months after pruning, without damaging the diaphragm. Chicot necrotisation rates varied with each vintage, particularly in 2020, the year immediately following the first maintenance pruning. When long pruning cuts preserved 2–3 cm of cane above the diaphragm, the desiccation cones were blocked, leaving the sap flow unimpeded.

KEYWORDS: quality maintenance pruning, young vines, necrosis length, necrotic wood, diaphragm, Ugni Blanc.

INTRODUCTION

Grapevine Trunk Diseases (GTDs), which are widespread throughout the world, make 13 % of vines in French vineyards unproductive (Bruez *et al.*, 2013). Esca is one of the most important GTDs caused by fungi. The woody necroses are caused by fungi, principally *Phaemoniella chlamydospora* (Pch), *Phaeoacremonium minimum* (Pmin) and *Fomitiporia mediterranea* (Fm) (Bertsch *et al.*, 2012). These tracheomycotic fungi, particularly Pch, obstruct the xylem vessels (Pouzoulet *et al.*, 2014). This obstruction impacts the sap flow and also the transport of the microorganisms, including the GTD fungi. Although Esca is a vascular disease, it also affects grapevine organs, particularly the berry, whose chemical components affect the quality of musts and wines from red or white cultivars (Bruez *et al.*, 2022; Lorrain *et al.*, 2011; Poitou *et al.,* 2021).

Besides internal woody necrotisation, the grapevines can express esca-foliar symptoms for one year and may reappear two years later (Maher *et al.*, 2012). The longer the vine continues to express Esca-foliar symptoms, the closer it becomes to dying. Since the use of sodium arsenite for controlling GTDs was banned, no efficient alternatives have been found. Alternative methods against pathogenic fungi employ various biocontrol agents, ranging from bacteria (Haidar *et al.*, 2016), oomycetes (Yacoub *et al.*, 2020) or certain specific fungi (Compant *et al.*, 2013).

Prophylactic methods against GTDs can prevent infection and decrease the risk of pathogenic fungal contamination. Pruning wound protection using a biocontrol agent, *Trichoderma* sp. (Mondello *et al.*, 2018), varied greatly according to the weather conditions for each vintage. The use of Carbendazim and Flusilazole, a chemical product, did not provide permanent wound protection after pruning (Halleen and Fourie, 2016). However, a molecule named Tebuconazole, used against *Eutypa lata*, gave interesting results after two years of study (Ayres *et al.*, 2016). Other attempted solutions include endotherapy, initially used on apple and avocado trees (Bourdrez *et al.*, 2014), and subsequently adapted to grapevine by a research team from Colmar. Endotherapy is used to kill the fungi, especially the Basidiomycota, *F. mediterranea*, by injecting bismuth salicylate into the white rot. Initial results seemed to show the efficacy of this method against *F. mediterranea* (Merlen, 2022).

Two other alternative methods, curettage and pruning, have been described in an earlier paper (Bruez *et al.*, 2022; Cholet *et al.*, 2021).

Curettage, removes the white rot and necrotic tissues of the plant, while also eliminating the pathogens. Cholet *et al.* (2021) showed that this practice kept the plant safer and helped to prolong vineyard life. The non-application of this method in Charente can be explained by the fact that a time-consuming process which costs far more than complantation, the most common practice.

Pruning is undertaken to control growth and fruit yield and to maintain the structure of the vine over many years. It leads to internal necrotisation and may have an impact on the fertility of shoots (De Krey *et al.*, 2022; Faúndez-López *et al.*, 2021; Gramaje *et al.*, 2018). During the first four years after planting, formation pruning is applied to constitute the Guyot–Poussard structure. This is followed by maintenance pruning. The results of a previous study, in Charente (Bruez *et al.*, 2022), on one 16-year-old vineyard, had already confirmed that short and long pruning exerted different impacts on desiccation cone formation. Short pruning, which damages the diaphragm, generated more necrosis, whereas long pruning, which leaves a chicot to protect the diaphragm, showed less necrosis. The diaphragm is a natural barrier against the necrotisation process following pruning. For the present trial, our study began at the maintenance pruning stage to compare the effect of different pruning types on necrosis development.

For such annual vine maintenance, pruning secateurs should be used to remove the shoots on the cordon, leaving the length of chicot required for the following physiological cycle. This cutting process inevitably induces pruning wounds, leading to the formation of a dead wood desiccation cone zone. Such injuries, in turn, trigger either physical or chemical barriers. As the grapevine is a liana, it does not develop a healing callus for its pruning wounds, and cannot maintain a healthy cell-producing membrane (Tippett and Shigo, 1981). The grapevine developed a defence system, CODIT (Compartmentalization of Decay in Trees), first described for trees in the late 19th century by Hartig (1891) and, more recently, by Shigo and Marx (1977). The initial model was based on observing the progressive compartmentalisation mechanisms of tissues following pathogen attacks. Partitioning the affected zone protects the cell-producing membrane, thereby restraining pathogen progression. Whereas the physical barriers prevent obstruction of the sap path vessels, chemical barriers, like tyloses and gums, limit the spread of microorganisms (Thorne *et al.*, 2006). However, as vessel closure is often too slow to restrict grapevine pathogen colonisation, the vine then goes on to produce tylose, a gummy substance that protects xylem vessels throughout the summer (Sun *et al.*, 2018).

The present study aimed (i) to analyse the impact of short and long pruning on the woody tissue necrotisation and (ii) to observe the number of fertile shoots, over a period of 3 years.

In the present study, one modality for short pruning and four modalities for long pruning were examined. The data obtained (i) show the interest in desiccation cone installation and (ii) determine the impact of pruning on necrosis length.

MATERIAL AND METHODS

1. Location and characteristics of the trial vineyards

The trial concerned two Ugni Blanc parcels, Parcel 1 and Parcel 2, planted in 2014 and 2015, in the vineyards managed by JAS HENNESSY & CO, at Juillac-le-Coq, in Charente. Parcel 1 is on sandy soil and Parcel 2 is on gravelly soil.



FIGURE 1. Presentation of the five pruning modalities, A = short modality pruning damaged the diaphragm, B = long modality pruning left 1 cm of the woody part above the diaphragm, C = long modality pruning reserved 3 cm of the woody part above the diaphragm, D = long modality pruning left the woody part up to the spur (5–6 cm), but removed the bud, E = long pruning kept the entire woody part up to the spur (5–6 cm), and also preserved the bud.

The one 4-year-old parcel and the 5-year-old parcel were pruned by the company's own on-site pruners in January 2019, 2020 and 2021 from the very beginning of maintenance pruning.

The two parcels were set out in double Guyot–Poussard and two different types of pruning quality, short and long, were applied. In both parcels, less than 5 % of the plants expressed Esca-foliar symptoms each year. In the plants used for the experimentation, no Esca-foliar symptoms were present.

One modality (Figure 1A) employed short pruning, and the other four modalities involved long pruning. Only short pruning, represented in red (Figure 1A), damaged the diaphragm. The first long pruning modality, in purple (Figure 1B), left 1cm of woody part above the diaphragm. The second long pruning modality, in blue (Figure 1C), preserved 2–3 cm of the woody part above the diaphragm. The third long pruning modality, in green (Figure 1D), left the woody part up to the spur (5–6 cm) but removed the bud. The last long pruning modality, in white (Figure 1E), kept the entire woody part up to the spur (5–6 cm), and also preserved the bud.

The trial, which started in 2019, studied one hundred plants for each of the five modalities shown in Figure 1. Twenty plants per modality were reserved for the fertile shoot analyses. For the other vines, samples were taken four and eight months after the maintenance pruning day. As this is a destructive method, one desiccation cone, per sampling time, was cut from each of the five plants. A total of ten plants was used annually, per parcel for each modality. The sampled plants were then removed from the experimental design, as they could still be used as vines in the vineyard.

2. Necrosis analyses

All the desiccation cone zones, spur diameters and necrosis lengths were analysed. Woody necrotisation is a natural process that can be accelerated by the pathogens involved in GTDs. The desiccation cone samples were first cut longitudinally, to observe their internal necroses. Each sample was initially soaked in 5 % sodium hypochlorite, to distinguish between living wood (yellow-green) and necrotic wood (beige-brown), and then examined using a flatbed scanner Hitachi X-300 (Hitachi, Ltd, Japan). The external necrosis, observable after removing the bark, showed no additional infection. That confirmed our decision to focus exclusively on internal necrosis.

Software ImageJ (Java software, NIH, Maryland, United States) was employed to analyse the images, with the protocol for calculating the necrosis being adapted from the procedure pioneered by Abramoff *et al.* (2004). This software allowed us to calculate necrosis lengths and the proportion of necrosis between the top of the cut and the diaphragm.

3. Fertile shoot analyses

In 2019, 2020 and 2021, the notations of budburst and the number of bunches were observed on twenty plants per modality on the two parcels at the beginning of April and middle of April and at the beginning of May for the bunches. To eliminate bias, the same person observed budburst at the same Parcel and the same vines. The phenological

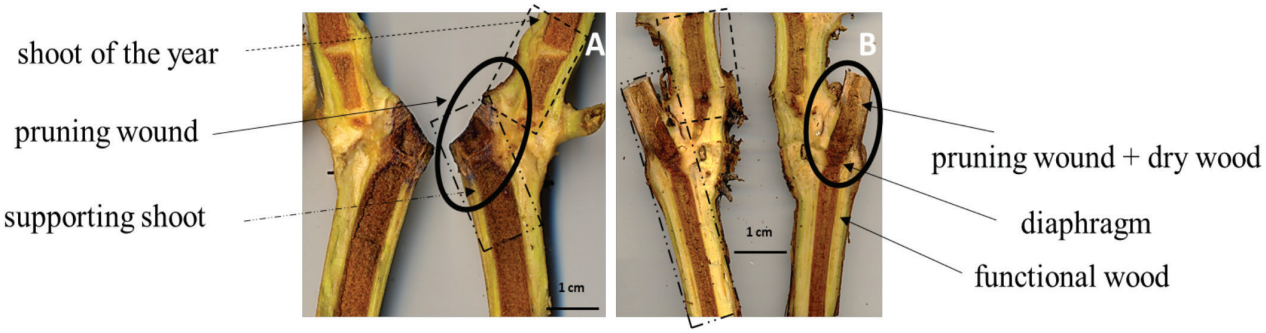


FIGURE 2. Description of Ugni blanc tissue types according to pruning: short (A) or long (B).

stages A (00-02 BBCH scale, 1 Eichhorn and Lorenz scale) and B (03-05 BBCH scale, 3 Eichhorn and Lorenz scale) showed that budburst had not developed. Whereas the phenological stages C (05-09 BBCH scale, 5 Eichhorn and Lorenz scale), D (06-10 BBCH scale, 6 Eichhorn and Lorenz scale) and E (11-13 BBCH scale, 7 and 9 Eichhorn and Lorenz scale) did show a budburst. After the complete bud burst, the number of bunches per shoot was counted. The ratio of the number of bunches to the number of buds indicates the percentage of fertile shoots.

To compare the budburst according to the weather, the day temperatures and the day rainfall data come from a weather station based at Juillac-le-coq (Charente). Data were analysed from January 1st to April 30th each year.

4. Statistical analyses

Statistical analyses were performed using R software (R Core Team, 2016, Auckland University, New Zealand). To confirm whether or not our variables of interest differed with pruning type, variance analyses (ANOVA) were performed for each physiological parameter. Residual variable normality was tested using the Shapiro–Wilk test. Whenever the variation tests were not significant, a non-parametric test was used (Kruskal–Wallis test). The tests were considered significantly different when $p < 0.05$.

RESULTS

Both histograms show that the pruning resulted in 20–70 % necrosis below the damaged diaphragm for the short pruning (red modality) and above the diaphragm for the long pruning (purple, blue, green and white modality). Sampling times, four and eight months after short pruning, were the same for both parcels.

Long pruning results differed according to the specific modality employed. Parcel 1 (Figure 2A) purple modality,

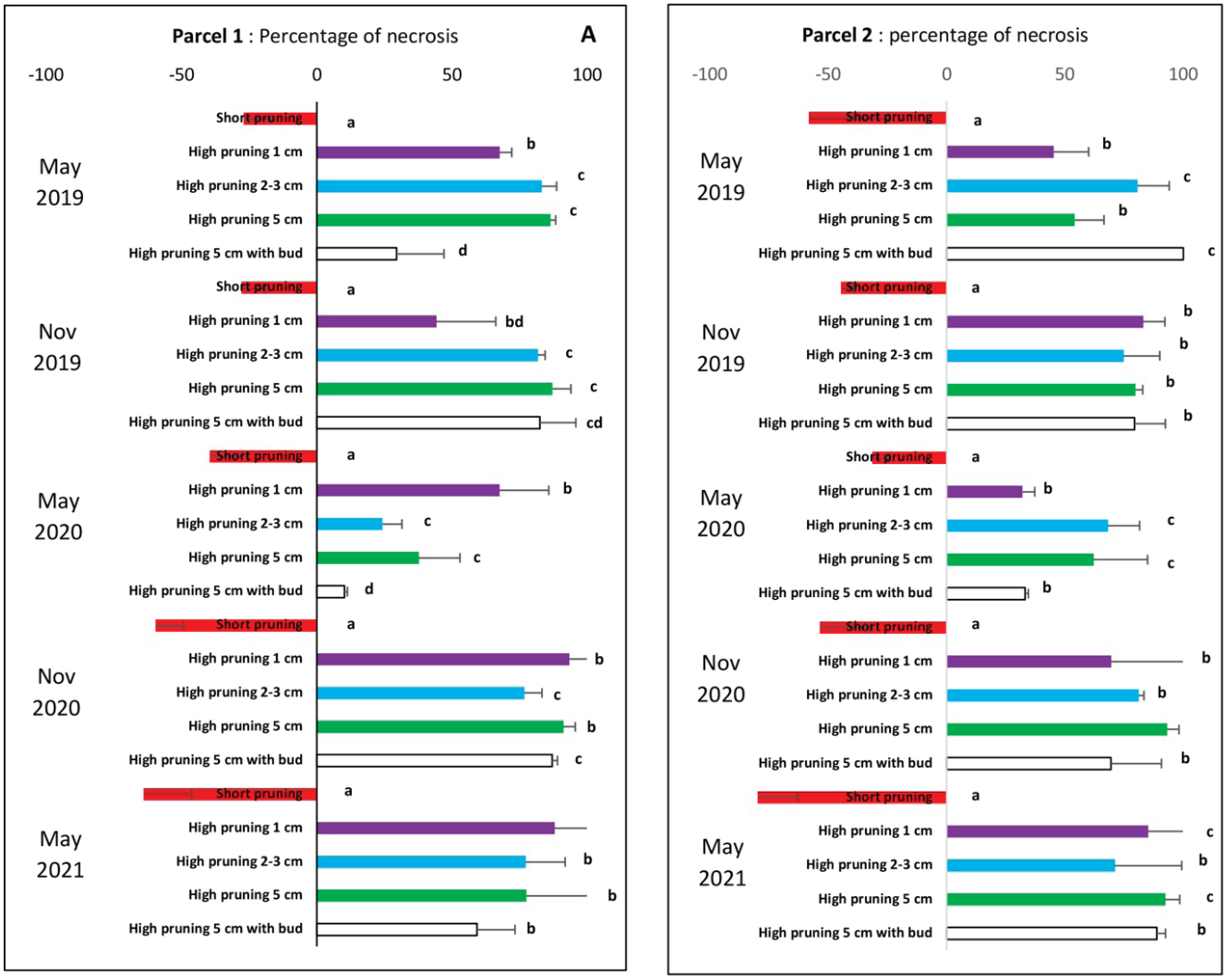


FIGURE 3. The histograms represent necrosis percentages of Parcel 1 and Parcel 2, below (–100 to 0) and above (0 to 100) the diaphragm (= 0). The short pruning modality, which damaged the diaphragm, is represented in red. The values represent the ratio of necrotic woody length and non-necrotic woody length below the diaphragm. The long pruning modalities are represented in purple, blue, green and white. The results show the ratio of necrotic tissue above the diaphragm to that of the cutting part. Value statistics are represented by letters from a to d.

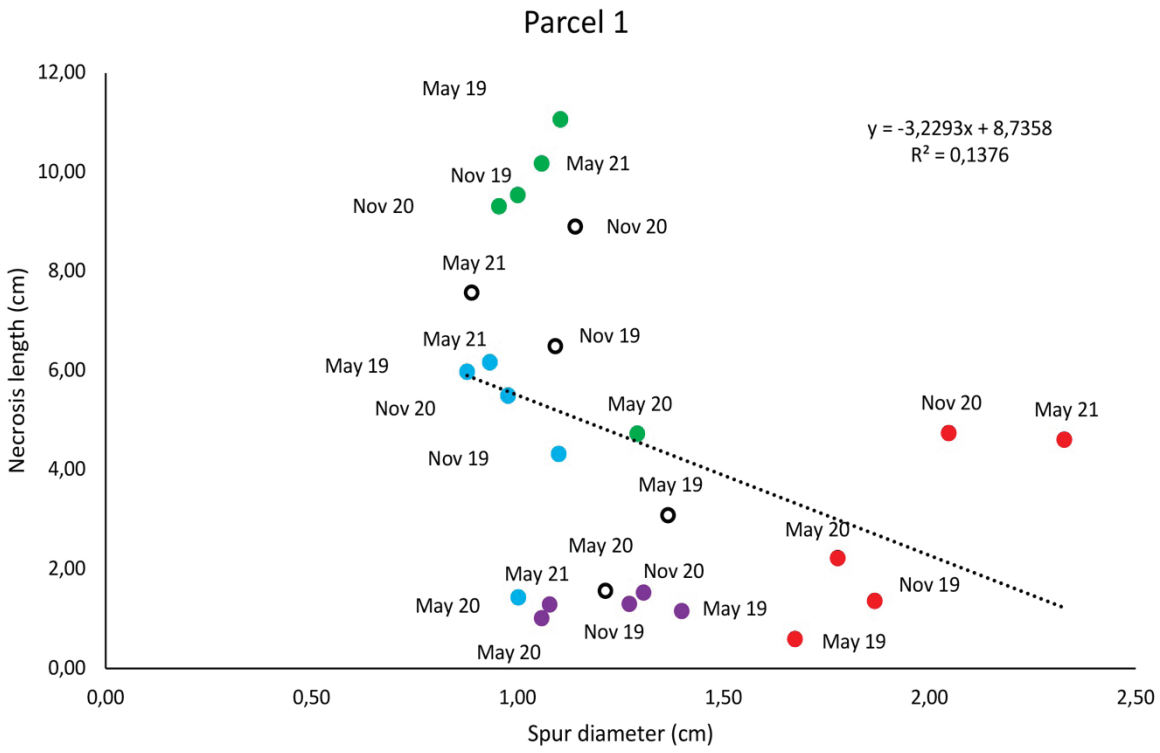


FIGURE 4. Correlation between pruning wound (spur) diameter and necrosis length in Parcel 1, from diaphragm to cut, 4 and 8 months after pruning in 2019, 2020 and 2021. The coloured points repre-sent the different modalities: red, purple, blue, green and white. Each point represents the average of 5 desiccation cone samples.

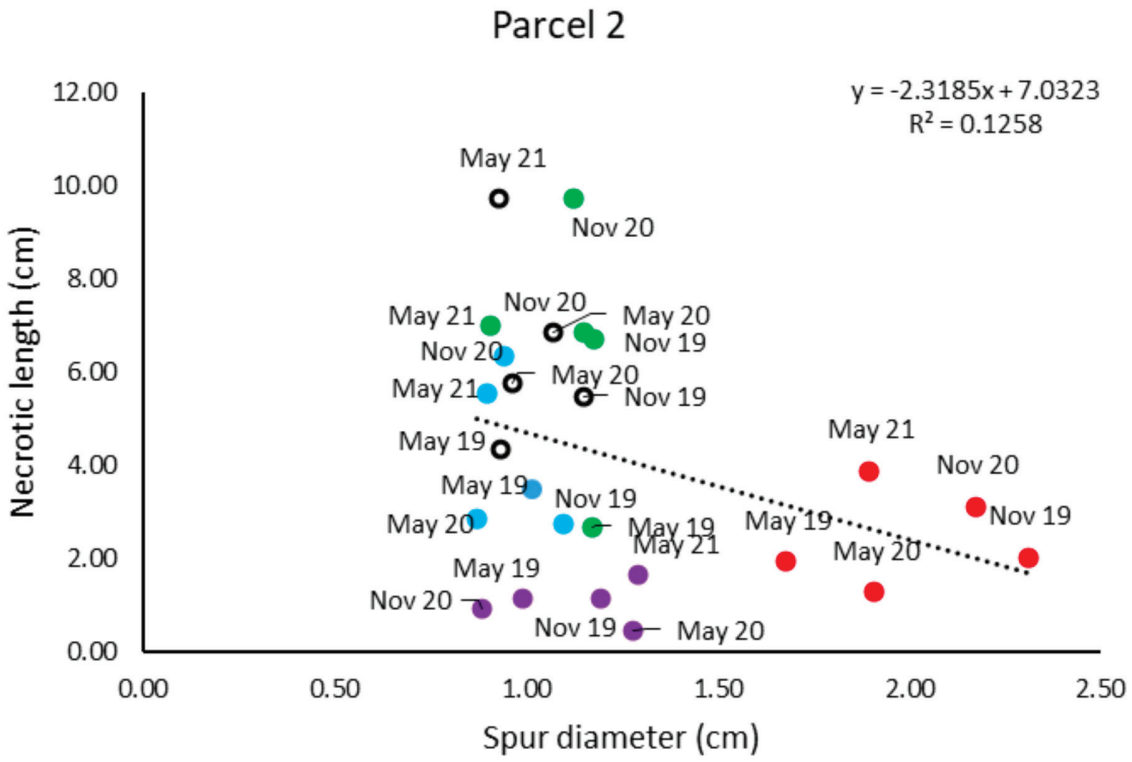


FIGURE 5. Correlation between pruning wound (spur) diameters and necrosis lengths in Parcel 2, from diaphragm to cut, 4 and 8 months after pruning in 2019, 2020 and 2021. The coloured points represent the different modalities: red, purple, blue, green and white. Each point represents the average of the 5 desiccation cone samples.

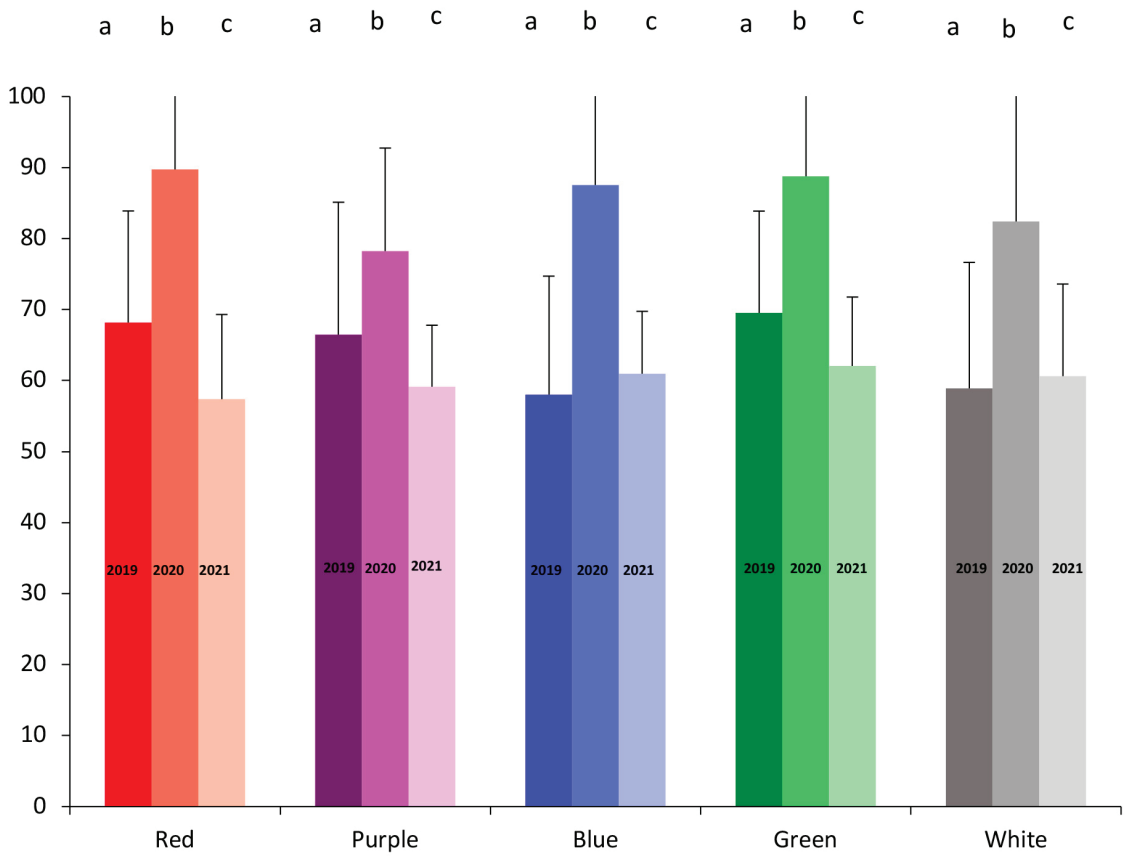


FIGURE 6. Percentage of Parcel 1 fertile shoots in 2019, 2020 and 2021. This is the ratio of the number of shoots per plant with and without bunches. The colours represent the different modalities: short pruning in red, and long pruning types in purple, blue, green and grey. Here the grey represents the white modality described in Material and Methods. The colour gradient represents the different vintages. Value statistics are represented by letters from a to c. It represents the comparison per modality each year, 2019, 2020 and 2021.

with a 1 cm woody part above the diaphragm, differed in May 2019 from the other modalities (p-value = 0.0089). In 2019 and 2020, the blue modality, with 3 cm of the woody part above the diaphragm, differed from the purple modality (p-value = 0.0092). Except in November 2020 (p-value = 0.0167), no differences were observed between the blue and green modalities. The safest pruning modality, shown in white, presented the least necrosis, particularly in May 2020 and May 2021 (p-value < 0.001), four months after pruning. Parcel 2 (Figure 2B), the purple modality, showed less necrosis than the blue modality. Differences in May 2019 and 2020 could be observed (p-value = 0.0151), but not in May 2021. For the blue and green modalities, no differences were observed, except in May 2019 (p-value = 0.545). The longest pruning, in white, showed more necrosis for Parcel 2 than for Parcel 1.

Figure 4 shows that for Parcel 1, in which each point represents the median desiccation cone per sampling date, there were no correlations between spur diameter and necrosis length (R2 = 0.138).

It should be noted that no differences were observed between different sampling years.

Figure 5 shows that in Parcel 2 there were no correlations (R2 = 0.129) for any of the five pruning types between spur diameter and necrosis length. Each point represents the median desiccation cone per sampling date.

The results in Figures 4 and 5 show that, even though there were no correlations between spur diameter and necrosis length, a similar grouping tendency could be observed.

For both Figures 4 and 5, the sampling results differed according to the year. No correlations were observed for different sampling times (summer or winter) (data not shown).

Figure 6 shows that after the first year of maintenance pruning, in 2019, no differences were observed. In the following year, no differences were observed between the modalities. However, differences were observed between the vintages. In 2020, the number of fertile shoots was the most abundant, with more than 80 % being fertile. That was not the case in 2019 and 2021, which showed a percentage of fertile shoots between 50 and 70 %.

Figure 7 shows that in 2019, the first year of maintenance pruning, the purple and the green modalities differed from the others. In 2020 and 2021, however, no differences were

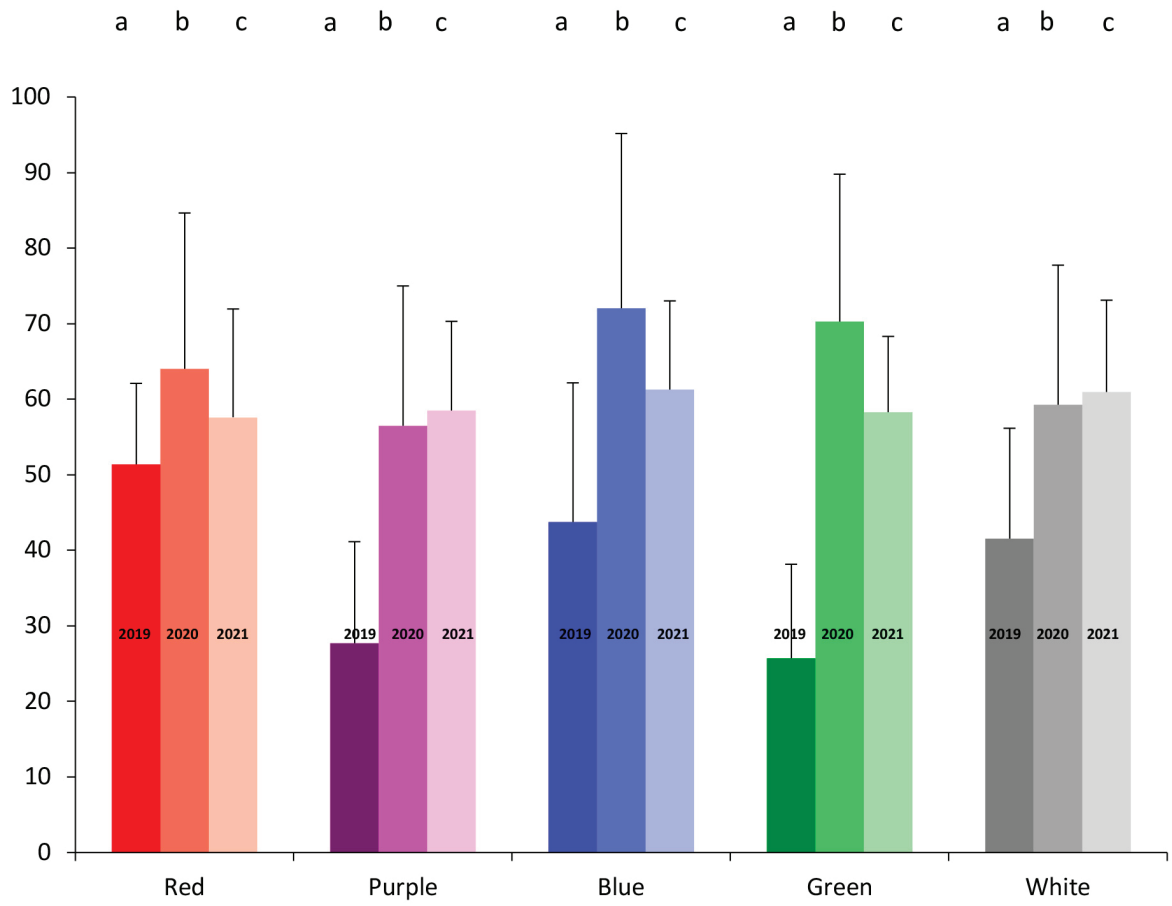


FIGURE 7. Percentage of Parcel 2 fertile shoots in 2019, 2020 and 2021. This is the ratio of the number of shoots per plant with and without bunches. The colours represent the different modalities: short pruning in red, and long pruning types in purple, blue, green and grey. Here the grey represents the white modality described in Material and Methods. The colour gradient represents the different vintages. Value statistics are represented by letters from a to c. It represents the comparison per modality each year, 2019, 2020 and 2021.

observed between all 5 modalities. As for Parcel 1, the greatest percentage of fertile shoots was in 2020.

Figure 8 shows that the spring season was warmest in 2020. The temperature curves stopped when there was at least 50 % of budburst.

DISCUSSION

The present study has focused on the importance of quality pruning for vine maintenance. Analysis of the data obtained revealed no correlation between spur diameter and necrotic length. An earlier study of three cultivars, Cabernet Sauvignon, Sauvignon Blanc and Ugni Blanc, also confirmed that small spur diameter did not systematically lead to short necrosis length (Bruez *et al.*, 2022). In Chile, this was also demonstrated by Faúndez-López *et al.* (2021) for Cabernet-Sauvignon.

Short pruning, repeated year after year, significantly increased the proportion of necrosis below the diaphragm. At the cordon level, short pruning accelerated tissue necrotisation, thereby irreparably damaging the sap flow path. Bruez *et al.* (2022) have already demonstrated this phenomenon in an old Ugni Blanc vineyard. When short pruning was applied at the start of maintenance pruning, the necrotic wood adversely affected sap flow paths. This severely limits vine vigour and production (Centinari *et al.*, 2016, O'Brien *et al.*, 2021). Our study leads us to strongly recommend the application of long modality pruning, from the very start of maintenance pruning.

It is important to keep the diaphragm safe by leaving a chicot, a part of the cane. In the present paper, four different modalities of long pruning were used. Our results confirmed the importance of keeping a 2–3 cm chicot, rather than one of just 1 cm. This is because necrotisation accelerates if the particular vintage is rainy, and the temperatures mild, as was the case in 2020.

Leaving a long chicot at the start of maintenance pruning, with or without the first bud, might seem to be a solution. However, in practice, it takes the vine pruners much longer to do that, and it also leaves an increasing number of shoots.

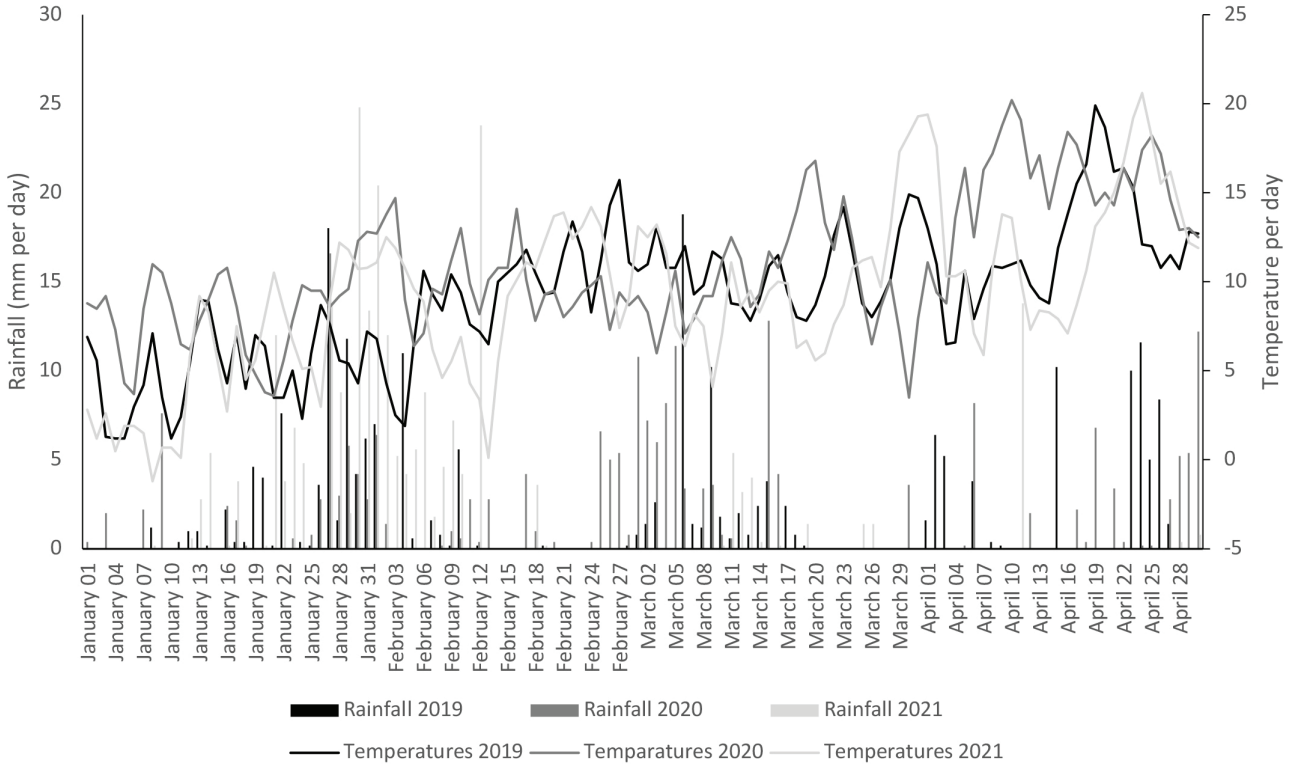


FIGURE 8. Temperature cumulation per day from January 1st until April 31st in 2019, 2020 and 2021. The histograms represent the rainfall and the curves of the temperatures per day.

The cumulation of temperatures was, in 2019 = 359 °C, 2020 = 390 °C and 2021 = 366.6 °C, 100 days after January 1st for each year.

For the vine grower, such an approach is not economically viable.

The results for fertile shoots differed according to the vintage. For Parcel 1, at least 50 % of the shoots were fertile. That was not the case for Parcel 2, which showed a very low percentage of fertile shoots. No differences were observed for short and long pruning in 2019 or 2020 and 2021. Faúndez-López *et al.* (2021) studied three cultivars in Chile over two years using two different pruning types, a short and a high one and no differences were observed.

Differences in shoot fertility were observed, particularly for Parcel 2 (Figure 7). In 2018, that parcel suffered from a spring frost. The results in 2019 were affected by this event. Centinari *et al.* (2016) explained that vines had frozen the year after the spring frost. That was the case in one of our two trials with a low percentage of fertile shoots in 2019 after the spring frost of 2018. In 2020, more than 50 % of the shoots were fertile. The vines of all Parcel 2 modalities recovered their fertile shoots.

Pruning showed no effects on the fertile shoots. However, for the short pruning, there seemed to be a greater number of fertile shoots in 2019 for both parcels (58 % for Parcel 1 and 51 % for Parcel 2), but this was not observed for the following year. The year after the 2–3 cm long pruning, the fertile shoots a good recovered in both experimental parcels.

The present study confirms the importance of leaving a 2–3 cm chicot from the very start of maintenance pruning. This is to limit internal necroses, thereby avoiding damage to the sap flow path.

We should recall, however, that maintenance pruning is preceded by formation pruning. During the first 4 years, such pruning is vital to set up the whole architecture of the vine. This prompts us to examine more closely the impact of formation pruning on the resulting necrosis development. A future trial is designed to address this question.

Our study demonstrates that a chicot of 2–3 cm is needed to avoid the colonisation of GTD pathogens. A second additional study could also focus on the pathogens involved in the GTDs, and verify their colonisation in the chicot.

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