Impact of late winter pruning of Portugieser grapevines (*Vitis vinifera* L.) on yield components and grape composition

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Abstract

Postponing pruning until early spring has been shown to be an effective way of delaying vine phenology. We investigated the effects of the timing of late winter pruning on 'Portugieser' vines in northwestern Croatia (2021), on yield, berry primary and phenolic composition. Late winter pruning (at the time of budbreak of basal buds and when two to three leaves were separated) was compared with standard winter pruning. Late winter pruning at budbreak resulted in grapes with the highest total phenolic and anthocyanin content and the lowest sugar and flavonol content at harvest, while late winter pruning performed when two to three leaves were separated had the highest titratable acidity and lowest total phenolic content.

Keywords: grapevine, anthocyanins, late pruning, polyphenols

Introduction

Winter pruning is a canopy management procedure usually carried out during dormancy. Its main purpose is to maintain the training system of the vine and to regulate the yield and vegetative growth. It is known that winter pruning performed late in the season, when buds are already beginning to swell, delays bud-break by a few days, helping to avoid spring frosts, which is especially important in regions with cool climates (Poni et al., 2022).

Increased temperatures in spring and summer often accelerate flowering, ripening and harvest date, while the final stage of grape ripening (from veraison to harvest) usually occurs in the hottest months of July and August, resulting in grapes with higher sugar content, lower acidity and poor color development. This is a climate change-related phenomenon that is of increasing concern to grape and wine producers around the world. To mitigate these effects, several approaches exist in different wine regions of the world, including postverasion trimming and leaf removal apical to the cluster zone (Caccavello et al., 2017, Palliotti et al., 2013) and preveraison application of auxin (Böttcher et al., 2022).

One of the approaches to deal with high temperatures during ripening is to delay the onset of bud break by delaying winter pruning, with the assumption that this will delay vine phenology, delay grape ripening and cause the final stage of sugar and phenolic ripening to shift to cooler conditions after high summer temperatures. Delaying bud break by pruning at this time can be explained by apical dominance, in which basal bud growth is suppressed by bud break of apical buds of the cane, but then basal buds are forced to break after pruning (Friend and Trought, 2007, Keller, 2015). Therefore, postponing the winter pruning date seems to be an effective way to delay fruit ripening and improve grape chemical composition (Frioni et al., 2016, Frioni et al., 2019, Gatti et al., 2016, Gatti et al., 2018, Moran et al., 2019). Late winter pruning can have an effect on crop yield and improve grape and wine characteristics (Netzer et al., 2022). In warmer climates, late winter pruning can be an effective tool to improve vine water status due to delayed canopy development (Netzer et al., 2022).

Although late winter pruning is a promising tool to delay ripening, its effect depends largely on the timing of pruning (Frioni et al., 2016). The later in the season winter pruning is performed, the more it can affect floral primordium differentiation, flower development, fruit set and fertilization (Frioni et al., 2016). Extremely late winter pruning can result in unacceptably low yield. Repeating the treatment following years may further delay vine phenology, as repeating the same late pruning treatment on the same vines may result in excessive use of available reserves in the spring to support vegetative growth (Gatti et al., 2018). The aim of our study was to investigate the effect of late winter pruning on yield, berry primary and phenolic composition of field-grown ‘Portugieser’ (*Vitis vinifera* L.) grape variety.

Materials and Methods

A one-year study (2021) was conducted on ‘Portugieser’ (*Vitis vinifera* L.) grape variety grown in a vineyard in northwestern Croatia. The study was conducted on the Jazbina experimental field of the Department of Viticulture and Enology, Faculty of Agriculture, University of Zagreb (long. 45°51'N, lat. 16°0'E). The soil type was anthropogenic pseudogley with clay texture. The vines were trained on the bilateral Guyot system, 80 cm above the ground. The rows were oriented northeast-southwest, with 2.1 m between rows and 1.2 m between vines (4000 vines/ha). The vines were grown using cultural practices common to continental Croatia.

Three pruning treatments were applied at different phenological stages based on the modified Eichhorn and Lorenz (E-L) scale (Coombe, 1995): E-L 4 (budbreak of basal buds), E-L 9 (two to three leaves were separated), E-L 1 (winter bud phase- control). The study was set in a randomized block design with three blocks per treatment, each block containing 6 vines. Regardless of timing, all vines were pruned with 2 spurs with 2 buds and 2 canes with 10 buds, which had around 24-25 buds.

Yield was measured on the vine basis, together with counting the number of clusters per vine. Samples of grapes from all three treatments were harvested at the same time. Must samples were produced from the harvested grapes by crushing them. The basic parameters of the must are total soluble solids, titratable acidity and pH. The soluble solids content was measured with a hand-held refractometer and pH was determined with a pH meter. The titratable acidity was determined using the coloration pattern volumetric method according to the O.I.V. (O.I.V., 2001).

Randomly selected 100 berries per block were stored at -20°C. The grape skins were manually removed from the frozen berries and freeze dried. To obtain a powder, the skins were grinded with the MiniG Mill (SPEX Sample Prep, Meutchen, USA), and were stored at -20°C until analysis. The extraction of the phenolic compounds was carried out according to the method described by Tomaz et al. (2016). The separation, identification, and quantification of the phenolic compounds from berry skin extracts was performed on an Agilent 1100 series system (Agilent, Germany), equipped with DAD, FLD, and coupled to an Agilent Chem Station data-processing station according to the one described by Tomaz and Maslov (2016). The results are expressed in mg/kg dry weight (DW) of skin. All data were analyzed using the one-way ANOVA procedure, and when differences between treatments were significant, Tukey’s test at P>0,05 was used to separate the means, using the XLSTAT software v.2020.3.1. (Addinsoft, New York, NY, USA).

Results and Discussion

Late winter pruning performed at the time of the budbreak increased yield, which was attributed to a higher average cluster weight (Table 1), a concept also seen in Friend and Trought (2007), who demonstrated that pruning around budburst may improve yield in cultivars that have unbalanced crop load because of poor fruitset. Winter pruning at E-L 4 appeared to stimulate yield production and increase cluster weight, as late winter pruning could have triggered preferential bursting of buds with different inherent fertility (Petie et al., 2017). On the other hand, late winter pruning performed when two to three leaves were separated did not affect yield and cluster weight (Table 1). Contrasting results of late winter pruning regarding the effect of timing of treatment on yield have been reported, which demonstrates a complex interaction between vine growth, phenology and the environment. In the research of Petrie et al. (2017), the yield variation in the ‘Shiraz’ vines were primarily caused by changes in bunch number and berry mass. Late winter pruning performed 1, 2 or 3 weeks after budbreak reduced the yield of cv. ‘Malbec’ in Israel (Netzer et al., 2022). On the other hand, in the research by Frioni et al. (2016), winter pruning performed at budbreak did not affect vine growth, yield and grape composition at harvest, but when performed in May, yield per vine decreased due to lower berry and cluster number, as a result of source limitation to the developing cluster primordia. Late pruning can lead to reduced yield compared to standard winter pruning, possibly due to reduced bud fertility, fewer clusters per vine and smaller berries (Gatti et al., 2018, Zheng et al., 2017).

Treatment with late winter pruning reduced grape sugar content regardless of timing (Table 1), confirming the findings of other researchers that delayed winter pruning can delay fruit ripening (Allegro et al., 202, Buesa et al., 2022, Falginella et al., 2022, Gatti et al., 2018). Late winter pruning performed at the time of the budbreak also reduced the total acidity of the must (Table 1). Similar to our results, late winter pruning of cv. Merlot delayed grape ripening and lowered sugar levels and acidity at harvest (Friend and Trought, 2007). Late pruning treatments can result in shorter shoot lengths and delayed phenological stages for the early ripening cultivars (Ferrara et al., 2022).

Table 1. Yield and basic composition of 'Portugieser' grape juice from different late pruning treatments (2021)

	Control	LWP1	LWP2
Yield /vine (kg)	2,47 b	3,23 a	2,65 ab
Cluster weight (g)	134 b	189 a	153 b
Soluble solids (°Oe)	106 a	93 c	101 b
Titratable acidity (g/L)	8,2 b	6,7 c	9,3 a
pH	3,38 a	3,38 a	3,27 a

LWP1- late winter pruning performed at budbreak, LWP2- late winter pruning performed when two to three leaves were separated, data were analysed through one-way ANOVA, means are separated with Tukey's test at P>0,05

Late winter pruning at the time of budbreak resulted in grapes with higher total phenolic and anthocyanin content and lower flavonol content at harvest, whereas late winter pruning performed when two to three leaves were separated had higher titratable acidity, fenolic acids and flavan-3-ols content, and lower total phenolic content compared with standard winter pruning (Table 2). Late winter pruning, regardless of timing, increased the total stilbene content of 'Portugieser' grape skin. Similar results were shown by others. Buesa et al. (2022) showed that late pruning just before budbreak delayed grape ripening, resulting in grapes with higher anthocyanin concentration for similar sugar content at harvest.

Table 2. Polyphenolic composition of 'Portugieser' grape skin from different late pruning treatments (2021)

	Control	LWP1	LWP2
Delphinidin-3-O-glucoside	1445,12 a	1217,88 c	1341,98 b
Cyanidin-3-O- glucoside	472,65 b	231,15 c	613,73 a
Petunidin-3-O- glucoside	2374,16 a	2064,76 b	1921 b
Peonidin-3-O- glucoside	1753,82 a	1146,07 b	1709,8 a
Malvidin-3-O- glucoside	8704,9 b	10116,63 a	7116,68 c
Delphinidin -3-O-(caffeoyl) glucoside	119,31 a	114,58 b	99,56 c
Peonidin-3-O-(acetyl) glucoside	117,86 a	86,27 c	94,03 b
Malvidin-3-O-(acetyl) glucoside	1390,37 b	1796,89 a	1139,77 c
Delphinidin -3-O-(coumaroyl) glucoside	44,78 a	33,02 b	31,36 b
Malvidin-3-O-(caffeoyl) glucoside	330,39 b	388,45 a	228,75 c
Peonidin-3-O-(coumaroyl) glucoside	328,77 a	308,62 b	245,52 c
Malvidin-3-O-(coumaroyl) glucoside	1479,85 b	2345,22 a	1225,4 b
Total anthocyanins	18561,98 b	19849,54 a	15767,58 c
Myricetin-3-O- glucoside	456,32 b	503,8 a	448,46 b
Myricetin -3-O-glucuronide	35,39 b	57,37 a	8,58 c
Quercetin-3-O-galactoside	158,83 b	126,62 c	201,23 a
Quercetin -3-O- glucoside	5343,69 b	4958 c	5721 a
Quercetin -3-O- glucuronide	77,18 b	88,7 a	64,61 c

Kaempferol-3-O-rutinoside	408,76 b	399,12 b	513,56 a
Kaempferol -3-O- glucoside	201,34 a	219,71 a	192,66 a
Kaempferol -3-O- glucuronide	14,74 a	6,96 c	12,69 b
Izorhamnetine-3-O- glucoside	75,24 a	77,73 a	59,12 b
Total flavonols	6771,49 a	6438,01 b	6764,87 a
Caftaric acid	94,22 c	202,41 b	366,72 a
Protocatechuic acid	25,48 b	32,96 a	31,86 a
Total phenolic acids	119,7 c	235,57 b	398,58 a
Viniferin	3,7 b	3,57 b	4,22 a
Resveratrol-3-O- glucoside	281,47 b	302,51 a	309,52 a
Total stilbenes	285,17 b	306,8 a	313,74 a
Gallocatechin	150,41 c	240,69 a	220,95 b
Epigallocatechin	170,6 c	210,34 b	258,63 a
Procyanidin B1	150,45 b	176,89 b	222,41 a
Procyanidin B3	13,18 a	14,84 a	15,3 a
Catechin	72,92 c	120,98 b	164,38 a
Procyanidin B2	52,21 b	56,72 b	72,19 a
Epicatechin	2,07 b	2,76 b	12,79 a
Total flavan-3-ols	611,84 c	823,22 b	966,95 a
Total phenolic concentration	26350,18 b	27652,22 a	24211,42 c

LWP1- late winter pruning performed at budbreak, LWP2- late winter pruning performed when two to three leaves were separated, data were analysed through one-way ANOVA, means are separated with Tukey's test at $P>0,05$

Netzer et al. (2016) found that late winter pruning increased anthocyanin content in grapes, possibly due to the lower number of clusters per vine, resulting in a distribution of more assimilates to each cluster, or to better exposure of clusters to sunlight due to the more compact canopy. Performing late winter pruning when shoots were 10 cm long decreased sugar content, increased total acidity, and increased anthocyanin content in the study by Palliotti et al. (2017). According to Frioni et al. (2016), late spur pruning in May increased total anthocyanin and phenolic content, possibly as a result of smaller berry size. On the other hand, late winter pruning a few weeks after budbreak did not affect sugar, total acidity and total anthocyanin content of 'Maturana' grapes grown in the Rioja region of Spain (Zheng et al., 2017), and late winter pruning performed at the time of sap bleeding stage did not affect total anthocyanin and flavonol concentrations in 'Merlot' grapes from Treviso, Italy (Falginella et al., 2022).

Conclusion

Late winter pruning is a cost-effective canopy management practice that allows grape growers to cope with frost but also to postpone grape ripening to cooler temperature conditions. This study suggests that postponing the winter pruning date tends to have positive effects on grape quality compared to standard winter pruning. Late winter pruning can delay the ripening and harvest date of 'Portugieser' grapes without negatively affecting the basic fruit composition, as delaying pruning to budbreak resulted in grapes with the highest total phenolic and anthocyanin content and the lowest sugar content at harvest. More in-depth studies are needed to evaluate how the interaction between environmental conditions, variety, and the timing of late winter pruning affects the accumulation of sugars and berry color during ripening.

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