Postveraison Shoot Trimming Reduces Cluster Compactness without Compromising Fruit Quality Attributes in Organically Grown Sangiovese Grapevines

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Abstract: Vine performance following preveraison shoot trimming is well documented, but the consequences of this treatment later in the season are poorly understood. Here, a four-year study was conducted in a mature vineyard of Sangiovese (clone 12T) grafted onto Kober 5BB rootstock at a spacing of 1 m × 2.8 m (intra- and interrow) to analyze the influence of postveraison shoot trimming on vine growth characteristics, cluster architecture (cluster compactness), and yield from a physiological viewpoint. The treatments consisted of shoot trimming during post-veraison in a randomized block design with eight replications (six vines each). Three treatments were imposed when soluble solids reached 15 Brix in August (40 to 45 days before expected harvest): light trimming (14 nodes), severe trimming (10 nodes), and an untrimmed control. Following the treatments, vine growth characteristics, cluster morphology, and fruit quality attributes were measured. Postveraison shoot trimming (especially severe trimming) reduced cluster weight, cluster compactness, productivity, and total yield. Effects on fruit quality included lowering of Brix and pH, with minor effects on titratable acidity, yeast assimilable nitrogen, the anthocyanin profile, and total anthocyanins. These results demonstrated that postveraison shoot trimming can be a valuable production practice by reducing cluster compactness without compromising overall fruit quality in Sangiovese.

Key words: anthocyanin, Brix, growth, productivity, yield

The cultivar Sangiovese is the most important Italian winegrape used to make prestigious Tuscan wines such as Brunello di Montalcino, Nobile di Montepulciano, and Chianti. Although grown with both conventional and organic viticultural practices, production of organically grown Sangiovese has been increasing for the last few years as organic products meet quality and health standards (Pagliarini et al. 2013). A key feature of Sangiovese is that regardless of how it is grown, it produces tight clusters, which are categorized as moderately compact, semi-compact, and compact (Nelson-Kluk 2006). Clusters of such morphology have less of a cuticular barrier at the contact surfaces and are thus susceptible to fungal diseases during ripening, mostly *Botrytis* cluster rot, especially in organically grown grapevines. Other concerns related to tight clusters include the tendency to overcrop as a result of the strong fruitfulness of shoots regardless of origin (primary, secondary, or basal buds), and a vigorous procumbent growth habit that leads to a dense canopy, which generally has negative effects on fruit quality, wood maturity, and maintenance of vine size (Poni et al. 2006).

Combating cluster rot to ensure profitable grape production has always been a challenge. For example, fungicidal spray is an expensive short-term fix as pathogens develop resistance to the chemicals over time; thus, it is unlikely that control of fungal diseases can be achieved by the use of fungicides alone. Organic viticulture requires an alternative, more environmentally benign approach because chemicals that are organically certified are generally ineffective at remedying cluster rot and lead to more environmental problems (Fragoulis et al. 2009). Another option is to use canopy management practices to improve cluster architecture and subsequently, the microclimate, by loosening the clusters, which minimizes fungal problems. For instance, defoliation decreased the number of berries and cluster compactness in Trebbiano and Sangiovese (Poni et al. 2006). Other practices that can reduce cluster compactness include cluster division (Molitor et al. 2012); drip irrigation (versus partial rootzone drying); spur pruning by hand, mechanical hedging, or minimal pruning; and combined irrigation and pruning to affect the number of clusters per vine and the rate of berry maturation (Leong et al. 2006). From a rootstock perspective, cluster compactness, berry skin strength, pedicel strength, and

the weight of cane and crop are strongly influenced by the choice of cultivar (Ferreira and Marais 1987). For example, clusters of Chenin blanc on Jacquez were significantly less compact than those on Ramsey or 110 Richter (Ferreira and Marais 1987).

A major principle of organic farming is the use of ecologically balanced protocols without chemicals, thus avoiding some environmental problems. Organic grape growers use eco-friendly production practices, with the exception of using copper when there is an immediate risk of infection (Fragoulis et al. 2009). Organic growers treat the vineyard as an interactive ecosystem (called a terroir) that consists of regional physical and cultural domains (e.g., climate and viticultural practices) through which yield and fruit quality can be optimized. Organic grape growers use a wide variety of canopy management practices, such as shoot topping (Molitor et al. 2015), shoot trimming (Martínez de Toda et al. 2013), pruning and leaf removal (Martin 1990), and hedging (Leong et al. 2006) to maintain healthy vines. Of these practices, shoot trimming is ideal for improving fruit and yield of organically grown Sangiovese as it is easily mechanized and relatively simple to perform. Shoot trimming involves pruning at different locations along the shoot and is generally used to facilitate the movement of people and equipment between vineyard rows, to reduce vine vigor, to avoid shade from overhanging shoots, and to facilitate harvest in grapevines with upright trellis systems (e.g., vertical shoot positioning) in cool viticultural areas (Hatch et al. 2011). Since it is used more to facilitate cultural operations, little information is available about the effects of shoot trimming on vine performance and fruit quality, especially for trimming performed late in the season after veraison. Previous studies examining shoot trimming were carried out early in the season (preveraison) and examined reproductive growth, yield, ripening, and fruit and wine quality (e.g., Keller et al. 1999), all of which varied widely in response to the treatment. Furthermore, none of these studies examined vine growth characteristics and cluster morphology, which have a strong influence on the incidence of fungal diseases, especially in organic viticulture. This is the first study that demonstrates a positive influence of postveraison shoot trimming, reflected in reduced cluster compactness and fruit yield, in organically grown Sangiovese, the production of which has been increasing during this decade.

Materials and Methods

Plant material and experimental layout. The experiment was conducted over four years from 2008 to 2011 in a mature vineyard of Sangiovese (clone 12T) grafted onto Kober 5BB rootstock at a spacing of 1 m × 2.8 m (intra- and interrow) for a density of 3571 vines/ha located in a hot hilly area of Emilia Romagna Region, Italy (lat: 44°17′7″N; long: 11°52′59″E, elevation 117 m asl). The vineyard was established on diverse subsoils of alluvial deposits and has been managed organically since 2007, in accordance with Reg. EC 834/2007 (EC 2007). Vines were trained to a cordon de Royat training system consisting of a short trunk with a uni-

lateral cordon trained to one side of the trunk and extending from one vine to another. The vines were spur-pruned during winter to two count nodes equaling 12 to 14 nodes per vine. Noncount shoots (shoots arising from basal buds of the spur) were removed at the beginning, and the cluster number was adjusted by thinning. The vines were maintained without irrigation or fertilization throughout the experiment.

The treatments consisted of shoot trimming during postveraison in a randomized block design with eight replications of six vines each (144 vines in total). Each year, prior to imposing treatments, vines were trimmed twice to a normalized shoot length of 145 cm. Thereafter, three shoot-trimming treatments were performed when soluble solids reached 15 Brix in August (40 to 45 days before expected harvest). The treatments included light trimming (LT of 14 nodes), severe trimming (ST of 10 nodes), and an untrimmed control (CK, 18 nodes). Shoot trimming was performed manually using large pruners. After trimming, shoot length in CK, LT, and ST vines was 145, 102, and 64 cm, respectively. The amount of leaf area removed following trimming treatments and maintained on vines were measured in 2009 and 2010 growing seasons using a leaf-area meter (Li-CoR Biosciences) by removing all leaves in single plants per replicate.

Climatic data. During each season, climatic data (mean, maximum, and minimum daily air temperatures (T), relative humidity (RH), and total rainfall) were recorded from budburst to harvest from a meteorological station located close to the vineyard.

2008. In 2008, from budburst (26 March) to harvest (24 Sept), the average growing season temperature was 19.4°C, the maximum temperature (early August) was 34°C, and the average RH varied from 45.5 to 89.5%. Total rainfall from budburst to harvest (243 mm) occurred mostly during April through June.

2009. In 2009, the average temperature from budburst (3 April) to harvest (23 Sept) was 22°C, the maximum temperature (38.7°C) occurred on 23 July, and average RH varied from 43.1 to 100%. Total rainfall from budburst to harvest was 190 mm and mostly occurred in April and during the first week of July.

2010. In 2010, from budburst to harvest (27 Sept), the average daily temperature was 20°C, and the average RH varied from 39.3 to 92.8%; there was an abundance of rainfall (464 mm), which occurred mostly in the spring and prior to harvest date.

2011. The 2011 growing season had an average temperature well above the seasonal normal, with a maximum of 30°C occurring in August. From budburst to harvest (21 Sept), average RH varied from 40 to 70%, with the highest (92%) in spring and the lowest (38%) in late August. Total rainfall from budburst to harvest was 204 mm; most precipitation occurred during spring, and almost none during ripening.

Measurement of growth characteristics, yield, and yield components. Leaf area maintained on vines and removed by trimming was measured using a leaf-area meter (Li-CoR Biosciences), by removing all leaves from one vine per replicate and from one representative shoot per vine. Cane length and

pruning weight were determined during winter. All prunings were weighed fresh. Yield and yield components (number and weight of clusters) were measured when berries met the optimal universal set of criteria (Brix, titratable acidity [TA]) to determine the same harvest date for all treatments. This was determined by periodic sampling of berries starting in July. All treatments were harvested when berries attained the same maturity level, i.e., when the soluble solids concentration reached a minimum of 20 Brix and TA was <7.0 g/L, and by considering qualitative (e.g., berry ripening disorders) and health (e.g., cluster rot) status of the clusters. Cluster compactness was determined according to the 1983 OIV classification (OIV 1983). Chlorophyll was measured with a SPAD-502 chlorophyll meter (Minolta).

Analysis of fruit composition. At harvest, berry weight, soluble solids (refractometer PAL-1, ATAGO), TA, and pH (Crison Compact Titrator, Crison Instruments) were determined by randomly collecting 100 berries per replicate in each treatment. Must yeast assimilable nitrogen (YAN) was determined on the same samples according to Aerny (1996), and berry skin anthocyanins were measured by HPLC as described by Venencie et al. (1997). Briefly, for each sample, skins were peeled from 30 berries and were weighed and placed in 20 mL hydroalcoholic solution (EtOH:H_2O, 10:90 v/v) containing 15 mL distilled water and 2.5 g tartaric acid. The samples were homogenized with an Ultraturrax (IKA Labortechnik) and centrifuged for 5 min at 3000 g at 20°C. The final solution weight was adjusted to 100 g and pH 3.6. The samples were then macerated for 24 hr at 4°C in the dark and centrifuged (ALC International, PK121R) for 20 min at 1400 g. Thereafter, the samples were filtered under vacuum with Whatman filter paper 40 (porosity 8 µm). Skin anthocyanins were determined using a Waters 1525 instrument equipped with a diode array detector (Waters Corporation) and a reversed-phase column RP18 (5 µm pore size, 250 mm × 4 mm; Supelco). Signals were detected at 520 nm. The elution gradient consisted of solvent A: water/formic acid (10%, v/v) (Romil Ltd.); and solvent B: acetonitrile (Sigma-Aldrich). The binary gradient applied was as follows: 0 to 7.9 min, 96% A and 4% B; 7.9 to 23.0 min, 85% A and 15% B; 23.0 to 27.0 min, 80% A and 20% B; 27.0 to 43.0 min, 70% A and 30% B; 43.1 to 45.0 min, 96% A and 4% B. Anthocyanins were quantified by measuring peak area at 520 nm and were expressed as mg/g of berry skin. A calibration curve was prepared from standard solutions of purified oenin chloride (Sigma-Aldrich) with concentrations between 50 and 500 mg/L. For each treatment, eight field replicates (each from an experimental plot containing six plants) were measured. All field replicates were maintained separately and measured in the laboratory; the number of field replicates was equal to the number of analytical replicates.

Statistical analysis. Analysis of variance and comparison of means between treatments were performed using SAS 6.04 software (SAS Institute, Inc.). Means were compared by the Student–Newman-Keuls test ($p \leq 0.05$). Cluster weight and cluster compactness were subjected to Kruskal–Wallis nonparametric tests.

Results

Growth, yield, and compositional characteristics. The postveraison shoot-trimming treatments were imposed on the same vines each year so that treatment effects accumulated throughout the experiment, resulting in changes in growth and fruit quality attributes. For instance, the crop load (Ravaz index) increased with increased shoot trimming (Table 1); this needs to be interpreted with caution because changes in the yield-to-pruning-weight ratio were an imposed response, not a developmental response. On the other hand, berry weight declined similarly among the treatments during the first two years of the experiment (2008 and 2009). Berry weight remained the same in 2010 but differed during the final year (2011) following the adoption of organic production practices in 2007 (Table 1). This indicated that reduction in berry weight after shoot trimming was a cumulative process; however, possible effects of smaller vine size and warmer conditions cannot be ignored. Cluster weight and yield per vine declined starting in 2008 (Table 1). The amount of leaf area removed and remaining on the vine after shoot trimming differed among the three treatments (Table 1). Cluster compactness also decreased in response to shoot trimming, especially under severe trimming (Table 2). Regarding fruit composition, Brix values were reduced during the first two seasons (2008-2009), but no difference was observed during 2010 and 2011 (Table 3). No difference was observed in pH in 2008 and 2010, but differences occurred in 2009 and 2011 (Table 3). In contrast, TA and YAN were not affected by shoot trimming except in one year (Table 3). Similarly, the anthocyanin profile (cyanidin, peonidin, petunidin, delphinidin, malvidin) and total anthocyanins were unaffected except for peonidin and total anthocyanins in 2010, which declined in response to shoot trimming (Supplemental Table 1). In general, severe shoot trimming had the strongest effect on the measured variables.

Discussion

Shoot trimming causes tylose to form in xylem vessels below the cut ends as a sealing mechanism to prevent water loss and pathogen entry into the vine (Sun et al. 2006). Shoot physiology and growth characteristics change after trimming and after the cut ends are sealed, especially for shoots trimmed after veraison, which marks the inception of ripening (Poni and Intrieri 1996). The effects of postveraison shoot trimming are manifested in altered cluster and berry morphology and fruit composition. This was seen here, where cluster compactness was reduced (clusters were loosened) in Sangiovese, a cultivar known for vigorous growth and large, compact clusters (moderately compact, semi-compact, and compact) (Nelson-Kluk 2006). A similar effect was observed in Riesling and Pinot gris when shoot topping (shoots tipped off ~5 cm below the apex) was delayed until four weeks after the end of flowering (Molitor et al. 2015). Other canopy management practices that yielded similar effects included pruning and leaf removal (Martin 1990), but the reasons for reduced cluster compactness and the resulting effects on fruit composition were not clear. As in this study, reduced berry

Table 1 Growth characteristics, crop load, yield, and yield components in control, severely trimmed, and lightly trimmed, Sangiovese vines from 2008 to 2011.

Year/ treatment[a]	Pruning wt (kg/vine)	LA1[a] (m²)	LA2[a] (m²)	Yield (kg/plant)	Ravaz index	Cluster wt (g)	Berry wt (g)
2008							
CK	0.47 a[b]	4.5 a	–	5.6 a	11.9 b	332.0 a	2.2
ST	0.39 b	2.9 b	1.3	5.2 ab	13.3 b	318.4 ab	2.1
LT	0.25 c	2.4 c	2.5	4.7 b	18.8 a	282.6 b	2.0
Significance[c]	***	**	***	*	***	*	ns
2009							
CK	0.55 a	3.6 a	–	3.4 a	6.0 b	268.1 a	2.6
ST	0.42 b	2.8 ab	1.1	3.2 ab	7.6 ab	245.9 ab	2.5
LT	0.29 c	2.1 b	1.6	2.6 b	9.b	210.2 b	2.4
Significance	***	***	ns	*	**	*	ns
2010							
CK	0.66 a	2.9 a	–	5.4 a	8.2 b	294.5 a	2.5
ST	0.55 a	2.4 b	0.9	4.7 ab	8.5 b	260.5 b	2.5
LT	0.40 b	1.3 c	0.6	4.0 b	10.0 a	246.8 b	2.5
Significance	**	***	***	*	*	*	ns
2011							
CK	0.42 a	4.9 a	–	2.5 a	6.0 b	216.1 a	2.1 a
ST	0.32 b	2.7 b	0.8	2.2 a	6.9 ab	191.6 b	1.9 b
LT	0.21 c	1.9 c	1.2	1.8 b	8.6 a	158.9 b	1.8 b
Significance	***	***	*	**	*	**	***

[a]CK, control vines; ST, severely trimmed vines; LT, lightly trimmed vines; LA1, leaf area before imposing the treatments; LA2, leaf area after imposing the treatments.
[b]Means within a column followed by different letters are significantly different according to the Student–Newman-Keuls test (pruning weight, Ravaz index, LA, berry weight, yield) and Kruskal–Wallis test (cluster weight).
[c]*Significant at $p < 0.05$; ** significant at $p < 0.01$; *** significant at $p < 0.001$; ns, not significant.

Table 2 Cluster compactness (OIV rating) in control, lightly trimmed, and severely trimmed Sangiovese vines from 2010 and 2011 experiments.

Treatment[a]	Cluster compactness	
	2010	2011
CK	6.5 a[b]	7.3 a
LT	6.6 a	5.5 b
ST	5.6 b	5.6 b
Significance[c]	*	*

[a]CK, control vines; LT, lightly trimmed vines; ST, severely trimmed vines.
[b]Means within a column followed by different letters are significantly different according to the Student–Newman-Keuls test.
[c]*Significant at $p < 0.05$.

Table 3 Berry compositional attributes in control, severely trimmed, and lightly trimmed Sangiovese vines from 2008 to 2011.

Year/ treatment[a]	TSS[a] (Brix)	pH	TA[a] (g/L tartaric acid)	YAN[a] (mg/L)
2008				
CK	22.7 a[b]	3.30	6.8	
ST	21.5 ab	3.30	7.0	
LT	20.7 b	3.20	7.1	
Significance[c]	*	ns	ns	
2009				
CK	24.2 a	3.40 a	4.6	165 a
ST	23.4 b	3.30 ab	4.4	142 b
LT	23.5 b	3.4 b	4.9	140 b
Significance	*	***	ns	*
2010				
CK	20.9	3.11	7.0	106
ST	20.5	3.11	7.1	105
LT	20.6	3.13	6.7	116
Significance	ns	ns	ns	ns
2011				
CK	25.6	3.49 a	7.0	99
ST	25.4	3.45 b	6.9	91
LT	25.3	3.41c	6.7	81
Significance	ns	***	ns	ns

[a]CK, control vines; ST, severely trimmed vines; LT, lightly trimmed vines; TSS, total soluble solids; TA, titratable acidity; YAN, yeast assimilable nitrogen.
[b]Means within a column followed by different letters are significantly different according to the Student–Newman-Keuls test.
[c]*Significant at $p < 0.05$; ** significant at $p < 0.01$; *** significant at $p < 0.001$.

size and cluster weight loosened the clusters, leading to re-duced productivity and yield per vine, which was expected as berry and cluster weight are a function of productivity. This trade-off is a very desirable feature in organic viticulture because loosened clusters have increased epicuticular wax load and cuticle thickness and are thus less susceptible to cluster rot (Martin 1990). Low Brix, pH, and yield occurred as a result of the loosened clusters. This reflected constrained ripening associated with reduced leaf area following shoot trimming (Stoll et al. 2009). In contrast to our study, these attributes were drastically reduced in Grenache and Tempranillo when severe shoot trimming was performed after fruit set (berry diameter 3 to 4 mm) by excising the internode just above the distal clusters (Martínez de Toda et al. 2013). However, treatments similar to ours (trimming to the 10th

node early in the season [preveraison]) led to elongated clusters and increased yield and Brix (Cartechini et al. 2000), except when combined with nitrogen application, where shoot trimming decreased fruit quality (Keller et al. 1999). While Brix, pH, and yield were reduced, the anthocyanin profile and total anthocyanins remained unaffected by shoot trimming. Herrera et al. (2015) observed the same phenomenon when Merlot vines were subjected to severe canopy reduction during early stages of ripening. These studies confirm that many of the precursors for anthocyanin development accumulate during preveraison (Dokoozlian and Kliewer 1996), whereas postveraison anthocyanin accumulation is mediated by sugar-induced genes that encode enzymes in the anthocyanin biosynthesis pathway (Conde et al. 2007). Reserve carbohydrates provide a source of sugars that lead to accumulation of anthocyanins in trimmed shoots, and hydrolysis of these reserves is stimulated by pruning, leading to remobilization into sink organs (Clair-Maczulajtys et al. 1999). Conversely, shoot trimming during preveraison (Cartechini et al. 2000), or trimming shoots to two leaves per cluster, reduced polyphenols (including anthocyanins) due to inhibition of anthocyanin biosynthetic enzymes (Wu et al. 2013). The same phenomenon is responsible for losses of anthocyanins under high temperature (Mori et al. 2007), which explains the lower anthocyanin levels in 2011, a much warmer season than the preceding wet seasons that experienced high rainfall (190 to 455 mm) from budbreak to harvest. These results demonstrate that climatic differences play a major role in seasonal variations in growth and fruit quality attributes (Herrera et al. 2015). Titratable acidity, like anthocyanins, was not affected by the treatments. This was expected because grape berries synthesize acids in situ prior to veraison (Conde et al. 2007). In contrast, the accumulation of nitrogen as α-amino acids and ammonia (YAN) increases at the onset of veraison (Bell and Henschke 2005) and requires a continuous supply of photoassimilates (Perez and Kliewer 1982). Hence, it was not surprising that YAN declined with the removal of leaves during shoot trimming.

Since vine physiological status at a given phenological event determines morphological features and fruit quality attributes, the next step is to analyze cluster architecture and fruit composition of trimmed shoots in the context of vine physiology and growth characteristics to understand the mechanism behind the observed changes. Here, the results of postveraison shoot trimming were unexpected and led to accelerated senescence of the shoot system. When this happens, the source-to-sink ratio declines and subsequently the overall photosynthetic capacity is compromised (Poni et al. 2003). This occurs because the most photosynthetically active leaves during ripening are those at the top of the canopy and those arising from lateral shoots (Candolfi-Vasconcelos et al. 1994). These sources provide an abundant supply of assimilates that increase yield and Brix (Poni and Intrieri 1996), which did not occur in our study because of the severe shoot trimming after veraison. On the other hand, if shoots are trimmed lightly (e.g., shoot topping) early in the season (before veraison), Brix and yield increase because competing organs are eliminated

from the shoot tip (Cartechini et al. 2000). Based on these observations, source limitation appears to reduce Brix and yield. However, shoot trimming should enhance ripening by inducing lateral growth of photosynthetically efficient leaves for transport of assimilates into berries (Koblet et al. 1996). Compensatory lateral growth for supporting berries did not occur in our study because shoots trimmed after veraison induce little regrowth (Poni and Intrieri 1996).

Other consequences of postveraison shoot trimming relate to the imbalanced (decreased) source-to-sink ratio that results in a shift in sink strength (the ability to partition photosynthates to stems and roots more than to berries) (Kriedemann and Lenz 1972). In this study, roots in which sink strength was reduced by fruits, which have the highest sink potential (Minchin and Lacointe 2005), were the next strongest sink as a result of cytokinin synthesis, because tissues enriched with cytokinins attract assimilates (Ron'zhina 2004). Further support comes from the Ravaz index (yield-to-pruning-weight ratio), a measure of crop load and the source–sink relationship (Kliewer and Dokoozlian 2005), which increased with trimming. However, this result needs to be interpreted with caution because the Ravaz index increased mainly due to the loss of leaves and stems caused by trimming (more than 25% of shoot dry matter was removed in the severe trimming treatment). As a result, most of the assimilates released from fruits were mobilized into roots, which would help prevent the death of fine roots and would replenish sugars lost during budbreak and early summer growth.

The reduced sink strength of berries in shoot-trimmed clusters also reflects resistance to phloem flow (Minchin and Lacointe 2005) due to plugging of sieve plates with callose, a carbohydrate synthesized when vines go into dormancy (Bondada 2014). Callose synthesis can also be induced by abiotic stress (Bondada 2014); it is likely that the stress caused by trimming (Candolfi-Vasconcelos et al. 1994) might have accelerated early synthesis of callose, thus reducing sugar export into berries. Because postveraison berry expansion relies on phloem influx (Bondada et al. 2005), resistant phloem will reduce berry size by reducing sink strength. Although these premises lend credible physiological explanations for the lower Brix of shoot-trimmed clusters, they should be further evaluated in future studies.

Conclusions

Many cultural practices affect fruit quality in grapevines. This study on postveraison shoot trimming showed positive effects on cluster morphology and fruit quality, i.e., reduced cluster compactness and sugar levels, which resulted from a source–sink imbalance associated with the trimming. Despite reduced yield and sugar levels, overall fruit quality was maintained. This reflects adaptations by the grapevines to maintain homeostasis. Grapes with reduced sugar levels are desirable as they can be fermented into balanced wines with reduced alcohol content, qualities that are highly desired by consumers. From an environmental perspective, the cultural practice of shoot trimming is an ideal practice for organic viticulture, which aims to promote and enhance biodiversity

and soil biological activity. Hence, postveraison shoot trimming can be recommended to organic grape growers as an effective practice for reducing sugar levels and cluster compactness in Sangiovese.

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