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TRAINING TYPE, CROP LOAD AND SHADING EFFECT ON QUALITY COMPONENTS OF ITALIAN RIESLING GRAPE VARIETY

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Abstract

The study investigated the influence of crop load and grape berry exposure on the characteristics of Italian Riesling grapes from the Recaş vineyard, Timiş County, Romania. The research focused on vines managed under the Guyot training system, utilizing both single and double cordons, arranged in north-south rows. Evaluation of grape exposure encompassed strategies such as: complete (100%) and partial (50%) leaf thinning around the bunches. Sixteen distinct plots were established, organized into four blocks, to examine various management practices and thinning techniques. Vine vigor was assessed through measurements of pruning and leaf area, with harvesting schedules adjusted to achieve similar °Brix values across plots. Following berry sampling and processing, grape juice analysis was conducted, revealing that vines trained double Guyot generally exhibited superior grape yield. However, higher crop loads were associated with reduced leaf area, resulting in delayed veraison and impacting sugar accumulation. Crop load had a significant influence on grape berry juice acidity and pH level, depending also of training system. Overall, the findings underscored the importance of the leaf surface-to-grape yield ratio as a critical determinant of grape yield and juice quality.

***Key words**: Italian Riesling, Guyot training, leaf area, crop load, °Brix.*

INTRODUCTION

Training systems have an impact on canopy development, airflow, sunshine exposure, and vineyard management and microclimate, all of which adversely impact berry development and grapevine physiology (Kraus et al., 2018). The Guyot is one of the most common vine training systems in viticulture, noted for its simplicity and flexibility to different terroirs and grapevine varieties (Lanari et al., 2022). Guyot pruning develops an open canopy, which improves airflow and sunlight within the canopy, boosting photosynthesis and grape maturation (Del Zozzo & Poni, 2024).). According to studies, vines with Guyot training accumulate more sugar, resulting in higher Brix level and higher potential alcohol concentration in the wines (Sabbatini and Howell, 2010). Furthermore, better solar exposure result in better phenolic maturity, wine mouthfeel and colour (Minaar et al., 2020).

Crop load management is a key component of viticulture, given that it affects grape berry composition as well as final wine quality (Reynolds, 2022). Pruning, thinning, and cluster removal can all be used to control the number of grape clusters or berries on a vine (Reeve et al., 2018). Understanding the impact of crop load on grape berry composition is critical for vineyard management and producing optimal wine qualities (Luna et al., 2017). Crop load has a considerable impact on sugar accumulation in grape berries. Large crop load frequently results in less sugar accumulation resulting from increased competition among vine organs for nutrients and water (Tangolar et al., 2019). In contrast, lower crop load may stimulate higher amounts of sugar in berries, resulting in higher potential alcohol concentrations in wine (Nistor et al., 2021). According to research studies, higher crop load result in grapes with lower acidity levels (Kliewer & Dokoozlian, 2005). This is due to dilution effects, in which limited resources (water and nutrients) are dispersed among a larger number of berries, resulting in lower acid levels (Brunetto et al., 2020). Crop load adjustment can affect the concentration of phenolic compounds, including anthocyanins and tannins in grape berries. Research has shown that modest crop loads can produce appropriate phenolic maturity, which results in balanced wine phenol compounds (Mori et al. 2007). However, overly high or low crop load can cause phenolic composition imbalances, which impact wine quality (Poni et al., 2018). Moderate crop loads can increase the development of favourable aroma components, hence increasing wine flavourful complexity (Cataldo et al., 2021). In contrast, high crop loads may result in diminished fragrance richness and complexity, whilst low crop loads may result in too powerful flavours (Previtali et al., 2021). Shading can have a variety of impacts on grape physiology and metabolic activity, thereby influencing wine quality. Understanding these effects is essential for vineyard management strategies with the goal to improve grape quality and wine qualities (Basile et al. 2015). Shaded berries have lower levels of sugar than those exposed to direct sunlight. This is due to lower photosynthetic activity in shaded places, which reduces carbohydrate synthesis and the accumulation of sugar in the grape berries (Garrido et al., 2018). Shading also influences grape berry acidity, which is important for wine flavour and balance. Shaded berries have lower acidity levels than sun-exposed berries, due to lower malic acid decomposition in shaded places, which lead to higher malic acid levels and lower tartaric acid concentrations (Michelini et al., 2021). Anthocyanins, flavonoids, and tannins are essential phenolic chemicals that contribute to wine colour, mouthfeel and flavour (Blancquaert et al., 2019). Canopy shading may alter the synthesis and concentration of these chemicals in grape berries (Ma et al., 2021) According to previous research, shaded berries typically have lesser quantities of phenolic compounds, resulting in lighter-coloured wines with less tannin content and less complexities (Anić et al., 2021).

The aim of the research was to investigate the effects of crop load and grape berry exposure on Italian Riesling grapes and wine from the Recaș vineyard in Timiș County, Romania. Specifically, it focused on vines managed under Guyot training, assessing grape exposure through various leaf thinning techniques and their impact on grape and wine composition.

MATERIALS AND METHODS

Research site

The research carried on during 2020-2022 growing seasons, was located in a vineyard from the western part of Romania, near Timișoara, Romania, namely Recaș vineyards (45.5272° N latitude and 21.1875° E longitude) with its specific terroir and uniformity of the soil type, vine size and age, or training system. The soil type in the Recaș, is mostly loamy and consists of sand, silt, and clay in nearly equal amounts. This soil is noted for its fertility and ability to hold rainwater while providing adequate drainage. Furthermore, the soil is rich in organic matter, which increases its fertility and is widely available and suitable for viticulture, making it a good basis for grape development. The experimental vineyard comprised sixteen plots (organized into four blocks, with each block containing four plots). Each plot represented a unique combination of training method (single or double cordons) and leaf thinning technique (complete or 50%). This configuration allowed for the comparison of various management and thinning techniques. The Italian Riesling vines were trained using the Guyot system (single and double cordons). Single cordons consisted of one main horizontal shoot, while double cordons had two horizontal shoots trained along the trellis wires. The vines were organized into north-south rows to optimize sunlight exposure. Leaf thinning was conducted to regulate sunlight exposure to the grape clusters and promote ripening. Grape exposure was assessed through two different leaf thinning techniques: a. complete (100%) leaf thinning (all leaves surrounding the grape bunches were removed); b. 50% leaf thinning (approximately half of the leaves surrounding the grape bunch were removed). Throughout the growing season, regular monitoring and data collection were conducted. Parameters such as vine growth, fruit development, cluster morphology, and grape ripening were assessed. Sampling was conducted at different stages of grape development, including veraison and harvest. Measurements included: cluster weight, berry weight, total soluble solids (°Brix), acidity levels and pH.

Weather data

Moderate temperatures (average temperature - 12.61°C) throughout the 2020 year and an average of 18.66°C between April to September, have contributed to gradual vine growth and balanced physiological development. The total precipitation amount in the Recaș area for 2020 was 862.3 mm. Adequate water availability has provided essential moisture for vine growth, particularly during critical stages such as bud break, flowering, and fruit set, nutrient uptake and photosynthesis, contributing to the overall vigour and productivity of the grapevine.

The average temperature for the 2021 year in Recaș vineyards was 12.59°C. This moderate average temperature indicates favourable conditions for vine growth and development throughout the year. From April to September, the average temperature rose to 19.23°C. This period corresponds to the growing season for grapevines, during which warmer temperatures support vegetative growth, flowering, and fruit development. The total amount of rainfall in the Recaș area for 2021 was 642.27 mm. While slightly lower than the precipitation recorded in the previous year, this amount still indicates sufficient moisture for vine growth and development. Spring and early summer have seen moderate to adequate rainfall, supporting healthy vine growth. However, there have been periods of dry weather during the late summer and early autumn, which have impacted grape yields and quality.

The weather in the Recaș area during 2022, characterized by moderate temperatures (average 12.74°C during the year and 19.35°C from April to September) and sufficient but slightly lower rainfall (414.8 mm), continued to provide favourable conditions for grapevine development. These conditions contributed to the production of healthy grapevines and high-quality berries, ultimately influencing the characteristics of the wines produced in the region.

Leaf area and grape yield/quality components

Leaf thinning was performed after flowering at berry set beginning, and 3 and respectively 6 basal leaves were removed from each shoot. Six vines were selected at random, both from those with single and double Guyot training. These six vines (totalling twelve in all) were chosen both from the plots with complete leaves thinning in the cluster area and from the plots with only 50% of leaf thinning. From the selected vines, leaves were removed and a sample of about 10% of their fresh weight was measured. A leaf image analysis system (WD-E3 WinDIAS Leaf Image Analysis System - AlphaOmega-Electronics, Maranata-Madrid S.L., Spain) was used to calculate the surface of the leaf/leaves. Grape yield was analyzed by counting and weighing the clusters on each of three selected vines in each plot.

Berry sampling was done starting from the last two weeks of August until berry maturation (around 20°Brix) and harvest (after 15 September for Single Guyot and respectively after 20 of September for double Guyot) in each growing season; every seven days, 50 berries were collected for analysis. In the laboratory, the berries were processed and analyzed for soluble solids (°Brix), titratable acidity and pH. Whole bunches were chosen randomly from the base, middle and top of the shoots on the vine. The collected bunches and berries were placed in labelled plastic bags and sealed and stored in cooler bags for transport.

Grape yield was determined by weighing grapes on a precision scale (Gramme EM-10K, Waagenet, Berlin, Germany). To analyse soluble solids, titratable acidity, and pH, the berries were crushed and blended with a magnetic stirrer (HI310N, Hanna Instruments). After filtration, the juice's soluble solids were assessed using a refractometer (HI96801, Hanna Instruments). Titratable acidity and pH were determined with a pH meter (HI98169, Hanna instruments).

Statistical analysis

Data collected from the sixteen plots were analyzed to evaluate the impact of different training methods and leaf thinning techniques on grape and wine quality. Calculations and statistical analyses were performed using GraphPad Prism software version 8.0 for Windows (GraphPad Software, San Diego, CA, USA). The comparison of means among different groups of numerical variables was conducted using one-way analysis of variance (ANOVA). Due to the non-normal distribution of most data, results are expressed as median, and a p-value less than 0.05 ($p < 0.05$) was considered statistically significant.

RESULTS AND DISCUSSIONS

Leaf area and weight

Grapevine training systems are essential in determining vine development, grape yield, and fruit quality (Heuvel et al., 2013). Among the different methods of training, the Single Guyot (SG) and Double Guyot (DG) systems are commonly used, each with their own particular characteristics (Kobayashi et al., 2020).

Table 1. The influence of Single and Double Guyot training on leaf area and weight in Italian Riesling variety

Guyot training	Year	% Thinning	Leaf area/vine (m^2)	Leaf weight/vine (kg)	Leaf area/main shoot (m^2)
Single Guyot	2020	100%	2.12	1.13	0.169
		50%	3.27	1.46	0.251
	2021	100%	1.97	1.06	0.151
		50%	3.11	1.48	0.238
	2022	100%	1.86	0.97	0.143
		50%	2.98	1.31	0.229
Double Guyot	2020	100%	1.46	0.74	0.113
		50%	2.53	1.17	0.194
	2021	100%	1.34	0.67	0.103
		50%	2.47	1.11	0.190
	2022	100%	1.18	0.58	0.097
		50%	2.14	1.03	0.165
p - value (two tailed)			0.0005	0.0005	< 0.0001
SD			0.6921	0.2880	0.0520
SE			0.1998	0.0831	0.0150
CV%			31.42	27.19	30.58%

The small p-value of 0.0005 (Table 1) indicates strong evidence of significant differences in leaf area per vine suggests that factors such as vineyard management practices, soil composition, or environmental conditions likely influence leaf area per vine, as Cataldo et al. (2020) found out in their research. The larger standard deviation of 0.6921 indicates greater variability in leaf area, which means that some vines have substantially higher or lower leaf areas than the average, which can be influenced by factors such as vine health, or local microclimate that affect leaf development, factors also mentioned by Van Leeuwen (2022) in his studies. Moderate to high variability (CV% of 31.42%) was found in the leaf area per vine, which may have implications for vineyard management decisions such as pruning practices for optimize grape yield and quality.

The observed differences in leaf weight per vine are statistically significant (p - 0.0005) that meaning they are likely to have practical implications for vineyard management and grape production. The standard deviation (0.2880) shows that there is moderate variability in leaf weight per vine among vineyard plots, treatments, or conditions under consideration. Understanding the variability in leaf weight per vine is critical in vineyard management since it can reveal information about vine health, vigour, and canopy development (Pereyra et al., 2023). The standard error of 0.0831, suggests that the sample mean leaf weight per vine is likely to be a reliable estimate of the population mean within the study population. The moderate to high variability (CV% of 27.19%) reveals that there are considerable differences in leaf area per main shoot among the samples, implying potential heterogeneity for this variable throughout the investigated samples.

The observed variability ($p< 0.0001$) for leaf area on the main shoot indicates that there are underlying factors or influences (environment, vineyard management, variety genotype) at play that are contributing to the observed differences in leaf area. With a standard deviation of 0.052, it infers that the data points for leaf area from to the main shoot exhibit relatively low variability. With a standard error of 0.015, the sample mean estimations of leaf area relative to the main shoot are very accurate. Results show a coefficient of variation of 30.58% indicates a moderate level of variability in the leaf area from the main shoot. This variability has implications for vineyard management decisions, as it can affect canopy density, sunlight exposure or grape ripening (Gatti et al., 2022).

Table 2. Training system and 100% leaves thinning influence on canopy in Italian Riesling (2020-2022)

Training system	Year	Thinning	Leaf area / vine (m^2)	Leaf weight / vine (kg)	Leaf area / main shoot (m^2)
Single Guyot	2020	100%	2.12^{**}	1.13^{*}	0.169^{*}
	2021	100%	1.97^{*}	1.06^{*}	0.151^{*}
	2022	100%	1.86^{*}	0.97^{ns}	0.143^{*}
Double Guyot	2020	100%	1.46^{*}	0.74^{ns}	0.113^{ns}
	2021	100%	1.34^{*}	0.67^{ns}	0.103^{ns}
	2022	100%	1.18^{ns}	0.58^{ns}	0.097^{ns}

(*for $p < 0.05$, ** for $p < 0.01$, and "ns" for not significant) based on a standard significance level of $\alpha = 0.05$

Across all three growing seasons, SG consistently outperforms DG in terms of leaf area per vine, leaf weight per vine, and leaf area per main shoot (Table 2). The differences observed between the two training systems are statistically significant, suggesting that the choice of training system has a significant impact on leaf characteristics for the Italian Riesling grape variety. Thinning, performed at 100% in both training systems, did not significantly affect the observed differences between SG and DG. While the differences between the two training systems are consistent across years, there is some variability within each system across different years, as indicated by the use of symbols.

Table 3.Training system and 50% leaves thinning influence on canopy in Italian Riesling (2020-2022)

Training system	Year	Thinning	Leaf area / vine (m^2)	Leaf weight / vine (kg)	Leaf area / main shoot (m^2)
Single Guyot	2020	50%	3.27^{**}	1.46^{**}	0.251^{**}
	2021	50%	3.11^{**}	1.48^{**}	0.238^{**}
	2022	50%	2.98^{**}	1.31^{**}	0.229^{**}
Double Guyot	2020	50%	2.53^{*}	1.17^{**}	0.194^{*}
	2021	50%	2.47^{*}	1.11^{*}	0.190^{*}
	2022	50%	2.14^{*}	1.03^{*}	0.165^{*}

(*for $p < 0.05$, ** $p < 0.01$) based on a standard significance level of $\alpha = 0.05$

The statistical analysis reveals consistent trends in leaf area per vine, leaf weight per vine, and leaf area on the main shoot across the three years for both training systems (Table 3). Single Guyot (SG) consistently outperforms Double Guyot (DG) in terms of these measurements, indicating that Single Guyot (SG) training may lead to higher leaf area and weight per vine as well as larger leaf area on the main shoot. The variability within each training system appears relatively stable over the three years, suggesting consistent performance within each system. However, the differences between the two training systems are significant, with SG consistently showing higher values compared to DG.

These findings suggest that the choice of training system can significantly impact leaf area, leaf weight, and leaf area on the main shoot, which in turn may influence grapevine growth, yield, and fruit quality. Winemakers and vineyard managers should consider these factors when selecting the most suitable training system for their vineyards.

Harvest time and berry quality

In order to obtain a similar sugar concentration (around 20 °Brix), the grapes were harvested with a difference of a few days in each growing season, the grapes from SG being harvested earlier.

To analyze the data, were conducted paired t-tests for each variable to compare the means between the Single Guyot (SG) and Double Guyot (DG) training systems at different thinning levels (100% and 50% respectively) for each growing season (2020, 2021, and 2022). The p-values indicate whether the observed differences between the training systems are statistically significant (Table 4). The statistical analysis conducted on the grape yield, bunches per vine, bunch weight, berry weight, total soluble solids (TSS), titratable acidity (TA), and pH levels across different years reveals insightful findings regarding the comparison between the Single Guyot (SG) and Double Guyot (DG) training systems.

Table 4. Comparison of Italian Riesling characteristics between Single Guyot and Double Guyot training systems at different thinning levels across three growing seasons (2020-2022)

Training system	SG	DG		SG	DG		SG	DG		SG	DG		SG	DG		SG	DG	
Year	2020						2021						2022					
Thinning	100%	100%	p	50%	50%	p	100%	100%	p	50%	50%	p	100%	100%	p	50%	50%	p
Grape yield (kg)	2.74	3.13	ns	3.15	3.43	ns	3.05	3.54	ns	3.40	3.87	ns	2.81	3.14	ns	2.98	3.48	ns
Bunches/vine	24.8	32.4	ns	28.3	34.3	**	27.2	33.2	ns	29.7	41.1	ns	26.4	35.6	**	30.1	37.5	**
Bunch weight (g/bunch)	114.2	97.8	**	112.6	100.8	***	112.9	107.3	*	117.4	94.4	**	121.3	89.7	***	119.6	94.1	***
Berry weight (g)	1.52	1.30	ns	1.50	1.35	ns	1.51	1.43	ns	1.57	1.26	ns	1.62	1.20	ns	1.59	1.25	ns
TSS (°Brix)	20.87	19.87	ns	19.95	20.46	ns	20.06	20.17	ns	20.19	19.43	ns	21.85	21.31	ns	21.23	20.14	ns
TA (H_2SO_4/l)	5.73	6.20	ns	6.23	5.92	ns	6.07	6.18	ns	6.12	6.31	ns	5.73	5.86	ns	5.95	6.11	ns
pH	3.09	2.99	ns	2.94	3.08	ns	3.12	3.20	ns	3.04	3.01	ns	3.27	3.31	ns	3.22	3.09	ns

($p < 0.05$; A p-value less than 0.05 indicate statistical significance; SG- Single Guyot; DG – double Guyot; TSS – total soluble solids; TA – titratable acidity)

The p-values for grape yield at both 100% and 50% thinning percentages were greater than 0.05 for all growing seasons, indicating no statistically significant differences in grape yield between the SG and DG training systems throughout the study period. This suggests that neither training system yields consistently higher grape production over the years.

At a thinning percentage of 100%, significant differences were observed in bunches per vine between the SG and DG training systems in 2021 and 2022 ($p < 0.05$). Similarly, at a thinning percentage of 50%, significant differences were found in 2021 and 2022 ($p < 0.05$). However, no significant differences were observed in 2020 for either thinning percentage. This implies that the SG and DG training systems may influence bunch development differently in specific years, but not consistently across all years.

Significant differences in bunch weight between the SG and DG training systems were consistently observed for both thinning percentages across all three years ($p < 0.05$). This indicates that the choice of training system has a consistent impact on the weight of individual grape bunches with one system consistently producing heavier bunches than the other.

For all thinning percentages and years, the p-values exceeded 0.05, indicating no statistically significant differences in berry weight between the SG and DG training systems. This suggests that both training systems yield comparable berry sizes and do not significantly affect berry weight.

Furthermore, both TSS and TA levels displayed no statistically significant differences between the SG and DG training systems and thinning percentages across growing seasons, as indicated by p-values greater than 0.05. This suggests that the choice of training system does not significantly influence the sugar content (TSS) or acidity (TA) of the grapes.

Similar to TSS and TA, the p-values for pH levels exceeded 0.05 for all years and thinning percentages, suggesting no significant differences in pH between the SG and DG training systems. This indicates that both training systems result in grapes with similar pH levels, suggesting no significant impact on grape acidity.

The results indicate that there are statistically significant differences between the Single Guyot and Double Guyot training systems for the variables bunches/vine and bunch weight (g/bunch) in 2021 and 2022. However, for the other variables (grape yield, berry weight, TSS, TA, and pH), there are no statistically significant differences between the two training systems across all three years. This suggests that the choice of training system may have a significant impact on certain grapevine characteristics (Del Zozzo & Poni, 2024) specifically bunch-related variables, in certain years. Further investigation may be needed to understand the underlying factors contributing to these differences.

CONCLUSIONS

The results of the statistical analysis shed light on the significant influence of training systems on leaf characteristics within the context of Italian Riesling grape cultivation. Across all three years, notable disparities were observed in leaf area per vine, leaf weight per vine, and leaf area on the main shoot between the Single Guyot (SG) and Double Guyot (DG) systems. Consistently, SG exhibited higher values for these parameters compared to DG, underscoring the pivotal role of the chosen training system in shaping vine development and canopy management.

While there remained a stable level of variability within each training system over the study period, the differences between SG and DG systems remained statistically significant. This consistency implies that vineyard managers can rely on the predictability of each system's performance, aiding in informed decision-making for optimal vineyard management practices.

Moreover, the study elucidated that thinning practices, applied in 100% in both SG and DG systems, did not substantially alter the observed differences in leaf characteristics. This underscores the paramount importance of selecting the appropriate training system to achieve desired outcomes in vineyard management.

Additionally, investigations into harvest time and berry quality revealed no significant disparities in grape yield, berry weight, total soluble solids (TSS), titratable acidity (TA), and pH levels between SG and DG systems across the study duration. While training systems may influence leaf characteristics, their impact on grape yield and quality parameters appeared negligible.

Nonetheless, notable differences in bunches per vine and bunch weight between SG and DG systems were noted in specific growing seasons (2021 and 2022). This variability underscores the multifaceted nature of environmental factors and management practices influencing grapevine development and highlights the need for further research to elucidate underlying mechanisms.

The findings underscore the critical importance of selecting the most suitable training system for vineyards, with SG showing consistent advantages in leaf characteristics. However, the variability observed in bunch-related variables emphasizes the complexity of vineyard management and calls for tailored strategies based on specific conditions and goals.

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