

INVESTIGATING THE IMPACT OF CLUSTER LOAD ON THE CHARACTERISTICS OF TWO WHITE WINE GRAPE VARIETIES ('KIRÁLYLEÁNYKA', 'FETEASCĂ REGALĂ' AND 'KERNER')

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Abstract

Globally, grapes are cultivated across 8.5 million hectares of land, with 60% of these grapes originating from Europe, where France, Italy, and Spain are the leading producers of both grapes and wine. The Carpathian Basin has a rich viticulture history that spans 2,000 years. This experiment aims to explore the effects of different cluster loadings (30% and 50%) on both the quantity and quality of yields from two grape varieties, 'Kerner' and 'Fetească regală' ('Királyleányka'). The study was conducted in Mica village, Mureș County. Results indicated that the control group yielded the highest quantities for both grape varieties. The 30% cluster load resulted in the highest sugar content and the lowest acid content, while the values at the 50% load were comparable. For producing high-quality wine, the 50% load was found to be the most effective, whereas the 30% load was more favorable in terms of the quantity of grape berries produced for both varieties.

Key words: cluster load, grape berries, viticulture, wine.

INTRODUCTION

Grapes worldwide occupies the fifth place in fruit production sector between 2000 to 2022 (Fao, 2023). In an environment of increasing competition in global markets, it is crucial to strive for elevated quality standards in the vineyard (Matese & Filippo Di Gennaro, 2015). Viticulture and winemaking hold significant socioeconomic importance in numerous European regions, the climate plays a crucial role in the terroir of a specific wine region, as it effectively regulates the microclimate of the vine canopy, the growth of the vines, their physiology, the yield, and the composition of the berries. These factors collectively shape the characteristics and distinctiveness of the wine produced (Fraga, 2019; Santos et al., 2020). Singh et al., 2017 mentioned that grape is the third cultivated fruit all around the world after citrus and bananas. According to the data gathered by International Organization of Vine and Wine from twenty-nine countries, which make up 94% of the global production in 2022, the projected world wine production (excluding juices and musts) for 2023 falls within the range of 241.7 mhl to 246.6 mhl. The midpoint

estimates stand at 244.1 mhl, this indicates a decline of 7% compared to the already below-average volume of 2022 (OIV, 2023).

In Romania the viticulture dates back for many centuries, with a long viticultural tradition (Patriche & Irimia, 2022; Chiurciu et al., 2020). According to report of the International Organization of Vine and Wine, Romania stands at the 10 places at the vineyard surface areas of major vine-growing countries in 2022 (OIV, 2022). Mălăescu et al., (2022) reported that Romania's climate and topography support the quality potential of grapes and wines, and production remains stable year after year.

According to Reeve et al., (2018) high quality growers of 'Pinot noir' reduce yield by cluster thinning to increase fruit quality, nevertheless, there are no clearly defined yield goals to reach optimal fruit composition. Thinning clusters throughout the growing season is a commonly employed technique in vineyard management with the goal of aligning crop yield with the vine's ability to properly mature the fruit (King et al., 2015). A study demonstrated that, crop thinning enhanced ripeness, reduced acidity, and heightened levels of anthocyanins and phenolics in Cabernet Sauvignon grapes grown in the

warm Riverland and Sunraysia areas of Australia (Petrie & Clingeffer, 2006). In another research is mentioned that cluster thinning increase Brix and im-prove wine aroma, colour, and flavour (Reynolds et al., 1996).

Balanced pruning resulted in an optimized yield by limiting the number of nodes to 30 per 454 g of dormant pruning's, additionally, cluster thinning was implemented to limit the number of clusters to two per shoots, this approach not only maintained the fruit composition but also improved the cold hardiness of the primary buds, it achieved an ideal fruit weight-to-pruning weight ratio of 10.0 kg·kg⁻¹ (Wilson et al., 2014). In a previous study it is determined that cluster thinning has not been consistently enhanced or refined the fruit chemistry (Smith & Centinari, 2019). However, in another study is also reported that cluster tip removal of inflorescences decreased cluster compactness, lowered titratable acidity, and increased total soluble solids in grape berries, however increased the levels of overall phenolics, anthocyanins, tannins, and flavonoids in the pedicel end of berry skins were found to be higher, along with increased concentrations of 12 phenolic compounds, additionally, the concentrations of total flavanols and anthocyanins in wines were also elevated (Liu et al., 2021).

Moreover, is also reported that grapevine's bud load is the quantity of buds remaining after trimming (Poni et al., 2016). Furthermore, the grapevine's optimal bud load is determined by the type of grape, the growth environment, and the intended yield (Dobrei et al., 2016).

The present study investigated the effect of cluster load of two white wine varieties 'Kerner' and 'Királyleányka'/'Fetească regală' to increase the quality and quantity of grape berry, furthermore to achieve a higher quality wine.

MATERIALS AND METHODS

The experiment was conducted in Mica, Mureş County in a vineyard in 2020.

The average temperature was 10°C (Figure 1) and the highest precipitation was in July approximately ~135 mm and the lowest August when 21 mm (Figure 2).

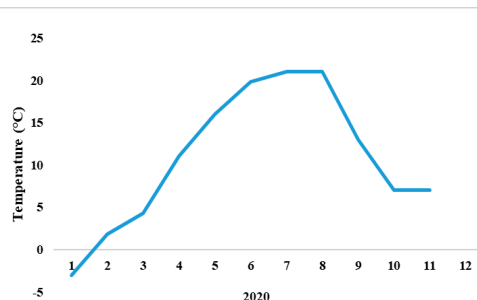


Figure 1. Temperature during the experiment

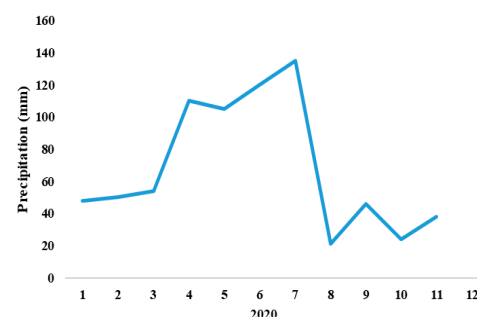


Figure 2. Precipitation during the experiment

The soil type was determined on the experimental site clay-washed, brown forest soil.

US 2. Clay-washed, brown forest soil (Table 1 and Table 2) (soils have moderate limitations that reduce the choice of plants or require moderate conservation practices).

Description:

Ap (0-10 cm) clayey – adobe, dark brown, granular structure, frequent root system, coprolitic, loose;

Ao (10-40 cm) clayey – adobe, dark brown, granular structure, frequent root system, coprolitic, loose;

Bt (40-68 cm) clay-washed, yellow-brown, prismatic structure;

Ck (68 cm) clay-washed, yellow, dense, lime concentration.

US 2. Luvisol

Description:

Ap (0-10 cm) clay-loam texture, dark brown, granular structure, frequent root presence, coprolitic, loose;

Ao (10-40 cm) clay-loam texture, dark brown, granular structure, frequent root presence, coprolitic, loose;

Bt (40-68 cm) leaching clay accumulation (illuviation), yellow-brown, prismatic structure; Ck (68 cm) leaching clay accumulation (illuviation), yellow, compact, lime concentration.

Table 1. Chemical analysis of US 2. soil

Horizont	Ap	Ao	Bt	Ck
Depth (cm)	0-10	10-40	40-68	68
pH	5.34	5.30	5.90	8.14
Humus	6.50	4.08	1.03	0.59
N %	0.311	0.183	0.076	-
P ppm	7	3	2	-
K ppm	18.5	8.1	10.2	-

Table 2. Physical analysis of US 2. soil (grain size analysis)

Horizont	Ap	Ao	Bt	Ck
Depth (cm)	0-10	10-40	40-68	68
Coarse sand 2-0.2 mm	1.9	2.7	0.7	0.2
Fine sand 0.2-0.02 mm	32.7	33.3	18	16
Powder 0.02-0.002 mm	28	31	29.4	40.1
Clay				

As plant material we have selected the 'Királyleányka'/'Fetească regală' variety which is native to Transylvania, Romania it is said that is a natural cross-breeding between 'Frâncușe' and 'Fetească regală'. The 'Kerner' is native to Germany from Weinsberg and it is a cross-breeding between 'Schiava Grossa' and 'White Riesling'. The cultivation area for the 'Királyleányka'/'Fetească regală' was 3 m² (2.5 × 1.2 m) pruned with short-pin pruning and for the 'Kerner' with snip pruning 2.25 m² (2.5 × 0.9 m).

In the study two types of treatments and one untreated (control) was set up. The treatments were carried out in 4 repetitions on 12 plants per repetition, so the effects of each treatment were examined on a total of 48 plants, per variety. The cluster thinning was made after the flowering stage, when the 50 and 30% cluster loads were set up, moreover in the case of control clusters remained in the same way. At the 50% cluster thinning in every case the shoot first cluster was kept, and the rest of the clusters were removed. In the case of the 30% cluster load, on the grape's productive bases from the two kept shoots from one of the shoots every cluster was removed, and from the other shoot the second and the third clusters were removed.

The parameters calculated: grape berry weight (g), cluster weight (g), harvest quantity (t/ha),

sugar content (g/L), acid level (g/L), dry matter content (%), and the number of seeds were evaluated.

The following methods were applied to determine the acidity, sugar, and dry matter content:

Determination of dry matter content:

Measurement of volume using a pycnometer for wine and water, along with distillation and subsequent calculations.

Removal of carbon dioxide from the wine through stirring.

Thorough rinsing of the pycnometer with the wine to be analyzed, followed by insertion of the wine and thermometer.

Adjustment of the wine to 20°C.

Filling the pycnometer to the mark, drying it, and weighing it to four decimal places.

Calculation:

Density = (mass of wine - mass of empty pycnometer) / mass of water.

Extract = 1 + wine density - distillate density.

Result interpretation using a reference table.

Calculation of Non-reducing Dry Extract:

Non-reducing dry extract = Total dry extract - residual sugar.

Determination of sugar:

Utilization of the Rebelein method.

Preparation:

In a flask, combine 10 mL of copper sulphate (CuSO₄), 5 mL of Seignette salt, a few grains of pumice stone, and 2 ml of the wine to be analysed.

Boil the solution for 2 minutes and allow it to cool.

Titration:

Add 10 mL of potassium iodide solution, 10 mL of sulfuric acid, and 10 mL of starch to the cooled solution.

Titrate the dark-colored solution with sodium thiosulfate until a yellowish-white color is achieved. Read the sugar content directly in g/L from the biuret. Dilution, if necessary, for sugar content above 28 g/L, dilute the wine with distilled water according to the specified factors.

Determination of total acidity:

Employment of the Schliessmann reagent/method.

Preparation:

In a flask, prepare 25 ml of the wine to be analysed, ensuring removal of carbon dioxide by heating and subsequent cooling.

Titration:

Titrate with BLAULAUGE 1/3 N solution until a dark green color is reached (indicating neutral pH, confirmed with pH paper).

The amount of sodium hydroxide solution used corresponds to the acidity of the wine.

The significance of the differences between the treatments was tested by applying one-way ANOVA, at a confidence level of 95%. When the ANOVA null hypothesis was rejected, Tukey's post hoc test was carried out to establish the statistically significant differences at $p < 0.05$ (Hammer et al., 2001).

RESULTS AND DISCUSSIONS

Comparing the cluster loads, could be clearly observed that significant differences were determined between the treatments at 'Kerner' variety (Figure 3). The greatest grape berry weight was recorded at the 30% cluster load at 'Kerner', with approximatively ~ 350 g. In the case of 'Királyleányka'/'Fetească regală' no significant differences were observed. Similar to our findings Fawzi et al. (2015) reported that increasing bud load on the vine significantly decreased berry weight and firmness.

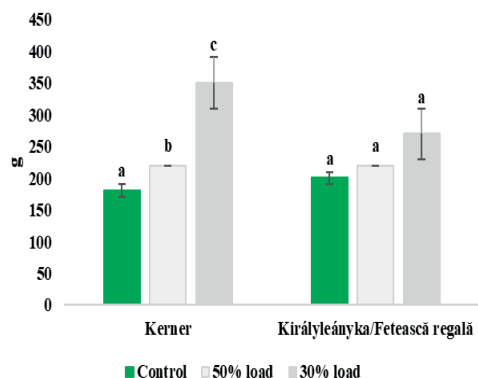


Figure 3. Grape berry weight under the effect of cluster load (50 and 30%). Bars represent the means $\pm$ SE ($n = 48$). Different letters above the bars indicate significant differences between cluster load ($p < 0.05$)

Regarding the cluster weight, again significant differences were recorded between the treatments at both white wine varieties (Figure 4). The cluster weight increases at 50% compared to control and it is followed by the 30% cluster load at 'Kerner'. Similar increase is observed also at the 'Királyleányka'/'Fetească regală'.

The greatest bunch weight was determined at the lowest crop load level (Somkuwar et al., 2014), as was reported in the present experiment. However, in a study is reported that cluster thinning did not affect the fruit composition and berry size at 'Cabernet Sauvignon' (Calderon-Orellana et al., 2014).

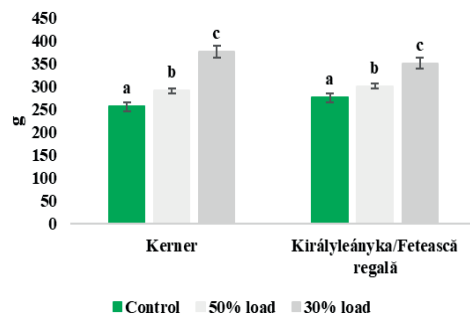


Figure 4. Cluster weight under the effect of cluster load (50 and 30%). Bars represent the means $\pm$ SE ($n = 48$). Different letters above the bars indicate significant differences between cluster load ($p < 0.05$)

As it was expected the highest quantity of grapes was recorded at the control plants, which is significantly different compared to the other treatments at both white wine varieties (Figure 5). No significant changes were observed between the two cluster load treatments (50% and 30%) at 'Kerner', on the other significant increase was reported at 50% cluster load compared to the 30% at 'Királyleányka'/'Fetească regală'.

In a study it was determined that the highest cluster weight was recorded by 8 buds/cane treatment (Khamis et al., 2017).

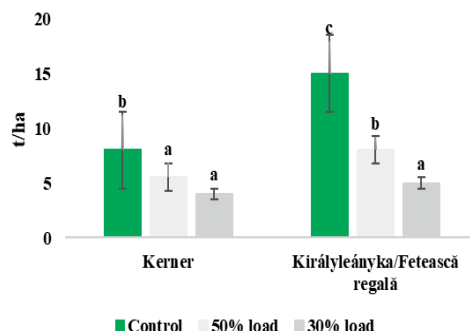


Figure 5. Harvest quantity under the effect of cluster load (50 and 30%). Bars represent the means $\pm$ SE ($n = 48$). Different letters above the bars indicate significant differences between cluster load ($p < 0.05$)

When comparing the sugar content of the two white wine varieties, no significant differences were determined (Figure 6). The sugar content at ‘Kerner’ was approximatively ~ 240 g/L and at ‘Királyleányka’/‘Fetească regală’ ~ 220 g/L. Regarding the sugar content in some authors determined that cluster thinning increased the sugar content (Tardaguila et al., 2008; Wang et al., 2022). However, in our case the sugar content was higher than at control, yet no significant differences were reported.

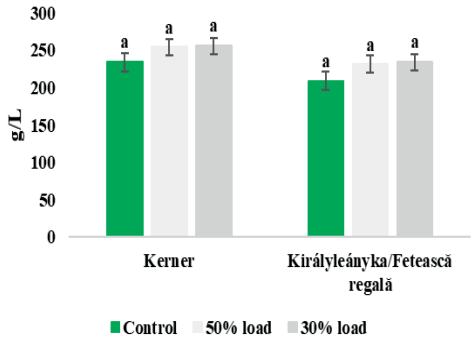


Figure 6. Sugar content under the effect of cluster load (50 and 30%). Bars represent the means $\pm$ SE ($n = 48$). Different letters above the bars indicate significant differences between cluster load ($p < 0.05$)

Here again, no significant changes were observed at the acid level (Figure 7). The cluster load did not influence the acid levels of the white wine varieties.

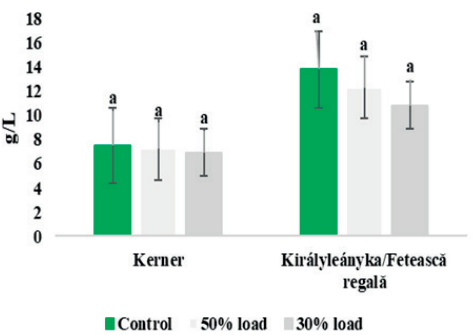


Figure 7. Acid level under the effect of cluster load (50 and 30%). Bars represent the means $\pm$ SE ($n = 48$). Different letters above the bars indicate significant differences between cluster load ($p < 0.05$)

In the case of ‘Kerner’ the acid level was approximatively ~ 7 g/L, and at ‘Királyleányka’/‘Fetească regală’ ~ 11.5 g/L.

Wang et al. (2022), reported that acid level was decreased by the effect of cluster thinning. Similar data could be observed also in our case when the acid level content was reduced by cluster thinning, however no significant differences were observed. Regarding the dry matter content (Figure 8), could be determined that at ‘Kerner’ variety significant increase was observed at the two cluster loads (50 and 30%) compared to control. On the other no significant increase was recorded at the ‘Királyleányka’/‘Fetească regală’ variety between the treatments.

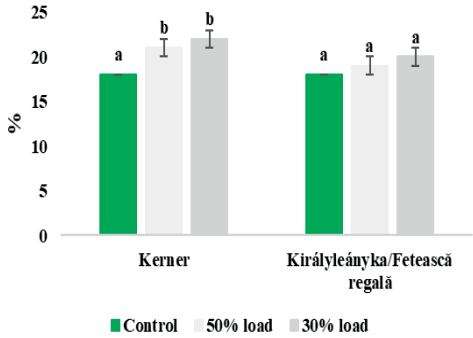


Figure 8. Dry matter content under the effect of cluster load (50 and 30%). Bars represent the means $\pm$ SE ($n = 48$). Different letters above the bars indicate significant differences between cluster load ($p < 0.05$)

At both cluster load treatments, the number of seeds increased at 1, 2, 3, and 4 seed/berry compared to control, and a decrease could be observed at the 0 seed/berry (Figure 9). Could be determined grape berry fertility increased, and at 30% cluster load was the highest.

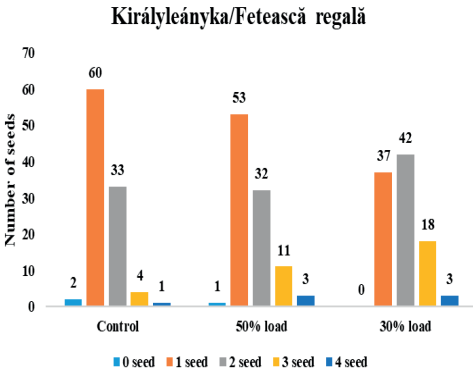


Figure 9. Number of seeds at ‘Királyleányka’/‘Fetească regală’ under the effect of cluster load (50 and 30%)

Here once again, the number of seeds increased at 1, 2, 3, and 4 seed/berry, and decrease was observed at 0 seed/berry (Figure 10). From the results could be determined that the grape berry fertility increased by the treatments, the highest seed number was reported at the 30% cluster load.

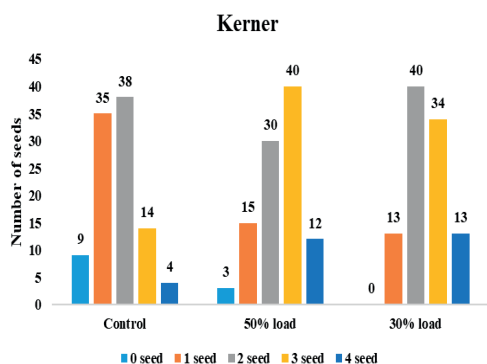


Figure 10. Number of seeds at 'Kerner' under the effect of cluster load (50 and 30%).

In some previous studies was reported that cluster thinning and its timing have little or no effect on shoot growth, leaf area, cutting weight, berry number, berry weight, and fruit composition (soluble solids, titratable acidity, pH, color) in the current and subsequent seasons. Differences in vegetative growth, yield development, and fruit composition within varieties are primarily due to season rather than yield or crop size (Ough & Nagaoka, 1984; Keller et al., 2005). However, other authors determined that grape composition more affected by cluster thinning severity than timing (VanderWeide et al., 2024). Increasing bud load up to the vine's capacity results in a greater distribution of carbohydrates in the fruit at the expense of vegetative tissue, which accounts for the majority of dry matter in the fruit (Miller & Howell, 1998). Furthermore, cluster thinning at an intensity of 35% produces wines with more terpenes, esters, higher alcohols, other alcohols, volatile phenolic compounds, lactones and other compounds compared to other treatments (Mucalo et al., 2022). Cluster thinning can also have influence on the metabolomic profile of the wine, to obtain the desired grape composition and wine quality (Škrab et al., 2021), and could also have a positive effect on the aroma and colour of the wine (Condurso et al., 2016).

CONCLUSIONS

The present experiment provides data on the comparison of cluster load effect on two white wine varieties ('Királyleányka'/'Fetească regală' and 'Kerner'). According to the obtained results, it can be concluded that the grape weight and cluster weight was significantly increased at 30% cluster load, on the other hand which was expected the highest quantity of grapes was observed at the control treatment. The sugar content and acid level were not affected by the cluster load treatments. Furthermore, the highest number of seeds at 'Királyleányka'/'Fetească regală' and 'Kerner' was determined at the 30% cluster load.

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