

**Corvinus University of Budapest**

**THE EFFECT OF TIME AND THE SEVERITY OF THE  
CLUSTER THINNING ON THE VEGETATIVE AND  
GENERATIVE PERFORMANCE OF THE ‘FURMINT‘ AND  
THE ‘HÁRSLEVELŰ‘ CULTIVARS IN TOKAJ**

Theses of Doctoral Dissertation

**György Lukácsy**

Budapest

2006

**PhD School  
Name:**

Doctoral School of Interdisciplinary Sciences  
(1. Life Sciences, /1.5. Biological Sciences/; 4.  
Agricultural Sciences, /4.1. Plant  
Production and Horticultural Sciences/)

**Field:**

Plant Production and Horticultural Sciences

**Head of Ph.D. School:**

Prof. Dr. János Papp  
Doctor of the Hungarian Academy of Sciences  
Head of Department of Fruit Sciences  
CORVINUS UNIVERSITY OF BUDAPEST,  
Faculty of Horticultural Sciences

**Supervisor:**

Dr. István Sándor Balogh  
Candidate of the Hungarian Academy of Sciences  
Head of Department of Viticulture  
CORVINUS UNIVERSITY OF BUDAPEST,  
Faculty of Horticultural Sciences

The applicant met the requirement of the PhD regulations of the Corvinus  
University of Budapest and the thesis is accepted for the defence process.

.....  
Prof. Dr. János Papp  
Head of Ph.D. School

.....  
Dr. István Sándor Balogh  
Supervisor

## Introduction

The producing vine area, the total wine production and wine consumption of the world have considerably decreased in the last two-three decades. Parallel with the decreasing wine consumption, the demand for the table wine decreased and it increased for the quality wine. The changes of the vine and wine sector forced the research and the practical application of certain viticultural, enological techniques, that are improving the grape and wine quality.

The applicable means for improving quality are restricted in case of a historical wine region as Tokaj. The narrow circle of the applicable cultivars and wine making technologies, the limited area of grape land in addition to the regulation of the wine region concerning the yield have put up the value of some viticultural operations, which are positively affecting the grape quality, while lowering the yield.

The two major cultivars of the Tokaj wine region, the Furmint and the Hárslevelű, are generally known as high yielding cultivars, their base buds can hold two or even three clusters, as well. The clones of the mentioned cultivars utilized nowadays can be characterized by higher average cluster weight than the basic cultivar (BÉNYEI and LŐRINCZ 2005). The marks of the overproduction (high yield, depressed shoot elongation, lower soluble solid and higher titratable acid content of the juice) can be noticed in some years even with the application of low bud and shoot load. To moderate the effect of the year it is required to optimize the reproductive and the vegetative production of the vine. In that case the reduction of the cluster number during the vegetation period can be advisable. Due to its advantages, the fruit thinning, one of the special types of the viticultural techniques, stands in the limelight and it is being utilized in a few vineyards of the wine region.

With the application of the fruit thinning, the number of the clusters the highest consumers of the assimilates are modified, this way directly and indirectly effecting numerous physiological pathways (intensity of the photosynthesis, translocation of assimilates) of the vine. While modifying the reproductive parts of the vine with fruit thinning, the vegetative productivity of the plant is also effected. The reduction of the number of clusters led to an increasing vigor of the shoots (WINKLER et al. 1974). Due to the effect of the thinning the pruning weight (BRAVDO et al. 1984, 1985a, 1985b, FISCHER et al. 1977), the length of the internode (MILLER et al. 1997), the size of the leaf plate (EDSON et al. 1993) and the leaf area index (LAI) (SMITHYMAN et al., 1998) can be increased.

The reduction of the cluster load creates a positive influence on the ripening of the cane (REYNOLDS et al.1996), which makes an impact on the tolerance of the vine for environmental stresses as excessive cold temperature at winter (STERGIOS and HOWELL 1977). Namely the stress, e.g. the drought tolerance of the vine can be increased by the cluster thinning (PONI et al. 1994).

Utilizing cluster thinning, the crop load does not decrease proportionally with the reduction of the number of the clusters, since the cluster weight (FEREE et al. 2002), the berry weight (OUGH and NAGAOKA 1984) increase, in addition the bud fertility improves, as well, due to the favorable circumstances at the bud differentiation (CARBONNEAU 1996).

The lesser or greater reduction of the yield leads to larger leaf area per unit fruit weight (KLIEWER and DOKOOZLIAN 2005), and lower yield/pruning weight (Y/P) ratio (MORRIS et al. 2004). According to BRAVDO et al. (1984) this ratio decreases even if the yield has not changed significantly.

A great number of researchers reported that the reduction of the number of clusters has caused advantageous changes in the characteristics of the juice and the wine. The most apparent particularity is that the sugar content of the juice frequently increases with the thinning (CARBONNEAU et al. 1977, FEREE et al. 2002, 2004, MÁJER and GYÖRFFY-JAHNKE 2005, WERNER and LŐRINCZ 2002), and the titratable acidity of the berries decreases (AMATI et al. 1994). OUGH and NAGAOKA 1984 reported that also the  $\alpha$ -amino nitrogen content of the juice increases with the severity of the crop reduction. According to the results of HEPNER and BRAVDO (1985) with the application of thinning the potassium increases and the calcium, magnesium decrease in the fruit.

The research of CORDNER and OUGH (1978), BRAVDO (1984) has proven the positive effect of the cluster thinning on the quality of the juice and the wine by the results of the wine tasting, as well.

According to the available, mostly international publications the reproductive and vegetative performances of the vine were modified in different degree, sometimes in different direction by the changes of the time and the severity of the operation. Based on the reviewed articles general instruction or "recipe" can not be concluded in connection with the exact time and severity of the operation. The advisable time and the severity of the treatment should be worked out in case of every site considering the cultivar and the target of the production.

The aim of the research was to determinate the optimal time and severity of the cluster thinning of the Furmint and the Hárslevelű cultivars, in Tokaj wine region examining the following aspects:

- The effect of the time and the severity of the thinning on the vegetative growth.
- The stress tolerance of the vine with the determination of the antioxidant protecting system, the peroxidase and the polyphenol oxidase enzyme activity and total phenol content of the tissues of the cane. The effects of the time and the severity of the cluster thinning on the value of the mentioned indices.
- The effect the time and the severity of the thinning on the balance of the vegetative reproductive organs of the vine.
- The effect of the time and the severity of the thinning on the yield and the quality of the fruit.
- The effect of the time and the severity of the thinning on the wine quality.

## Material and methods

The experiment was carried out from 2002 to 2004 in the vineyard of Tokaj-Hétszölő Ltd., 5 kms to the West from Tokaj, Hungary. The plot is situated on 180 m latitude, the soil is volcanic based loess with low humus content.

The examined cultivars were the Furmint (*Vitis vinifera* L.) and the Hárslevelű (*Vitis vinifera* L.) on the rootstock Teleki 5 C. The vines were spaced 1 m (between vines) x 1.8 m (between rows) and trained to royat cordon. Low bud load (3,3 bud/m<sup>2</sup>) and low shoot load (10-12 shoot/vine) was uniformly obtained in all three years of the investigation.

Fruit thinning was used at four phenological stages: berry set, cluster closer, veraison and ripening and two levels of severity: light, leaving 1 cluster/bearing unit (max. 6 clusters/vine) and sever, leaving 1 cluster/shoot (max. 12 clusters/vine). During the thinning operation the second and the third clusters of the shoot were always eliminated. Each treatment consisted of 25 vines and replicated three times. The treated vines were compared with the unthinned, control vines.

The vines were examined applying the method of CSEPREGI (1992), determining the total number of shoots, the number of bearing shoots, the number of clusters, the value of the absolute fertility coefficient (number of clusters/number of bearing shoots), the relative fertility coefficient (number

of clusters/total number of shoots) and the bud fertility coefficient (number of clusters/number of buds reminded after pruning).

The LAI (leaf area index) was indirectly determined by utilizing Accupar Decagon instrument.

During the ripening period the berry weight was measured by scales. Examining the juice the soluble solid was determined by densitometer, the titratable acid was determined by 0,1 n sodium-hydroxide titration , the pH was determined by Radelkis pH.-meter instrument and the yeast assimilable nitrogen by the method of DUKES and BUTZKE (1998). At harvest time the number of clusters per vine was counted, the yield was weighted and based on the mentioned parameters the average cluster weight was calculated. At harvest time the element content was determined by ICP-OES instrument and the free amino acid was determined by ion exchange chromatographic method from the juice samples collected.

In the dormant period the pruning weight, the diameter and the length of the 5<sup>th</sup> internode was recorded. At the biochemical examination of the canes the peroxidase enzyme activity was determined by the method of SHANNON et al. (1966), the polyphenol oxidase enzyme activity was determined by the method of JEN and KAHLER (1974) and the total phenol was determined by the method of SINGLETON and ROSSI (1965).

The fruit was processed in the all three years of the experiment and wine was made in microvinification. The wines were analyzed after the first racking. The alcohol and total extract were determined by the densitometry assay of the distilled wine, residual sugar was determined by the method of Schroll, the titratable acid was determined by with 0,1 n sodium-hydroxide titration, the pH was determined by Radelkis pH.-meter instrument and the total phenol was determined by the method of SINGLETON and ROSSI (1965). The fine composition of the wine (element, free amino acid composition) was determined similarly to the case of the juice.

The experimental wines were assessed by an 11-member committee. Wine quality was determined on 0 to 20 score system.

Ministat<sup>®</sup> software was used for data analysis. The data of the three years of experiment of each cultivar were analyzed by two-way (timing x severity) analysis of variance (ANOVA).

## Results and discussion

### *Growth*

The Furmint and the Hárslevelű vines have reacted to cluster thinning by an increasing vegetative growth. The thinned Furmint vines produced 40% higher pruning weight than the control in the three years average. Similar effect of the treatment was registered by the examination of the cane diameter. However the pruning weight of the Hárslevelű was more equalized in all of the years of the experiment, but the pruning weight increased significantly (average 14 %) due to the crop reduction. The cane diameter of the Hárslevelű cultivar remained unaffected.

The amount of the available portion of carbohydrates for the production of the vegetative organs increased, which could be recorded in larger pruning weight and leaf area index. Not only the relative, but even the absolute quantity of the assimilates translocating toward the remained consumer organs (shoot tips, old woody parts, roots) could increase, improving the carbohydrate supplement of the whole plant.

The time and the severity of the thinning had no significant influence on the vegetative growth of the vine.

### *The biochemical assessment of the canes*

The activity of the peroxidase and the polyphenol oxidase enzymes and the phenol content of the canes collected on the same date were significantly different on the applied treatments. The determination of activity of the stress enzymes and the quantity of the product of the secondary metabolisms were concluded to be a suitable method to follow the stress impact of the vines during the dormant period. The activity of the peroxidase and the polyphenol oxidase enzymes of the Hárslevelű cultivar decreased with the cluster thinning. The decrease of the activity of peroxidase enzyme in the cane of the severely thinned vines reached an average 50% compared to the control in 2003. Similar tendencies were recorded in case of the activity of the polyphenol oxidase enzyme in 2004. The high activity of the enzymes can indicate higher sensitivity for stress factors, or even stress situation. The results of the assessment of stress enzymes can also indicate that the fruit thinning has a positive effect on the plant hardiness.

### *Yield*

The absolute, the relative and the bud fertility coefficient of the vines increased with the cluster thinning. Greater fertility of the buds and shoots were recorded in the following year in case of the Furmint cultivar, which seems to be sensitive for overproduction when severe thinning was obtained at early phenological stage. Similar tendencies were noticed on the Hárslevelű cultivar after three years continuous undercropping. The buds of both productive vine cultivars treated contained average 0,5 clusters more than the control vines. The overcropping of the these very productive vines can continue to the years following the thinning, which is advisable to manage with higher severity of yield reduction.

The cluster weight increased significantly by the reduction of the clusters. The heaviest clusters were registered on the early and severely treated vines. In 2004 the average bunch weights of the mentioned treatments were approximately 450g in case of both cultivars, while clusters of the control vines remained under 350g. The explanation of the phenomena on the Furmint vines can be led back to the increasing berry weight. The berry weight of the early thinned vines was 25% higher than the control.

The yield of the Furmint did not decreased proportionally with the decreasing number of clusters. 61% reduction of the cluster number caused 50% reduction of the yield, while 36% reduction of the cluster number caused 20% of yield reduction in the three years average. The statistical survey did not prove any difference between the yield of the light thinned vines and the control in the three years mean. Higher yields were noticed on the vines of the early thinned treatments, while managing similar cluster number/vine. The vines thinned at berry set and cluster closer stage could catch up the loss of the crop reduction. Only in 2004 were similar tendencies registered on the Hárslevelű vines. In the three years average the yield decreased by the same proportion as the cluster number.

### *Vegetative-generative balance of the vine*

The leaf area per unit fruit weight has increased significantly by the fruit thinning in case of both examined cultivars. The leaf area/fruit weight ratio was 30% greater, when one cluster was left per every shoot and the ratio was 100% greater, when one cluster per bearing unit was developed.

The yield per pruning weight ratio decreased significantly by the thinning in each case. The ratio was over 14 in the three years average on the untreated vines of the Furmint cultivar, which was reduced by the light thinning

treatments to 7 and by the severe treatments to 5. The Y/P ratio of the untreated Hárslevelű vines was 7,1 in the three years average. By the effect of light thinning the ratio was reduced to 5, while applying severe thinning the ratio was reduced to 3.

The Y/P ratio of the examined cultivars decreased parallel with the decreasing number of clusters, while the time of thinning had no significant effect on the ratio.

The optimal range of the Y/P ratio is between 2 and 5 under the ecological circumstances of Hungary (BÉNYEI et al. 1999). According to BRAVDO et al. (1984) the signs of the overcropping appear clearly, when the ratio is over than 10. Based on the value of the Y/P ratio, the untreated vines of the Furmint cultivar turned out to be highly overloaded in the three years average. To optimize the balance between the vegetative and the reproductive organs severe thinning had to be used. Based on the Y/P ratio, even the untreated Hárslevelű vines did not prove to be overcropped. The optimal Y/P ratio was achieved by utilizing even the light thinning.

#### *The quality indicators of the crop and must*

The sugar contents of the juice of the Furmint and the Hárslevelű cultivars were favorably effected by the cluster thinning. The sugar content of the juice increased with the severity and decreased with the lapse of date of the thinning. The soluble solid content of the juice was 16% higher in case of Furmint and 14% higher in case of Hárslevelű than the control, when severe thinning was used until cluster closing. The differences among the treatments can be led back to the absolute and relative quantity of the carbohydrates translocating from the old woody parts towards the berries at the stage of veraison. The sugar content of the juice increased by the thinning, even if the yield did not decrease.

Based on the results of the three year experiment, on the basis of the valuation of sugar content, the fruit of the severely treated vines, thinned to one cluster at berry set and cluster closer stage, exceeded the quality standard of the base of the high quality wine of Tokaj. The differences between the vintages concerning the sugar content of the juice can be moderated by the application of early and severe thinning. In that case 23,8 Ref% soluble solid content was recorded in the three year average and the deviation was only  $\pm 0,3$  Ref% from 2002 to 2004.

However the sugar content of the juice of Hárslevelű cultivar was significantly modified by the treatments, but the differences between the vintages were just slightly lessened.

The effect of the time and the severity of the thinning on the titratable acidity of the juice have not been clearly proven in the recent experiment. The absolute value of the titratable acidity was considerably influenced by the vintage year. However in most case the titratable acidity of the juice changed oppositely to the sugar content of the berries. Based on the results of the experiment, the titratable acid content of the juice can dramatically drop by the effect of the early (berry set and cluster closer stage) thinning in dry years. In the recent study the titratable acidity of the juice dropped under 6 g/l in 2003.

The  $\alpha$  amino nitrogen and the total yeast assimilable nitrogen content of the juice increase with the fruit thinning, improving the circumstances of the alcoholic fermentation through the supplement of the yeast strains. Similarly to the sugar content of the berries, the highest value  $\alpha$  amino nitrogen and the total yeast available nitrogen were registered in the juice of the early and the severe treated vines. In case of the Hárslevelű cultivar the  $\alpha$  amino nitrogen content of the juice of the severe treated vines, thinned until cluster closer was 12% greater than the control ones.

The total free amino acid, the arginin and the prolin content of the juice decreased by the severity and the date of thinning. In case of Hárslevelű, 30% greater prolin and arginin content were recorded in the juice of the severe treated vines thinned at berry set, than the control. There was a close, positive linear correlation ( $R^2 = 0,87$ ) registered between the arginin and the  $\alpha$  amino nitrogen content of the juice of the Furmint cultivar. The reported observation should practically be taken into consideration by the nutrition of the yeast strains during the fermentation, if the fruit is healthy and free of noble rot or *Botrytis* infection.

The juice of the early and severely treated vines contained higher value of numerous macro and micro elements, as magnesium, which also improves the circumstances of the alcoholic fermentation. The potassium content of the juice expressed similar tendencies, which has a feed back effect to the titratable acidity and the pH of the juice. By the effect of the tartrates formation, the titrabale acidity decreases and the pH increases. The highest value of boron was recorded in the juice of the severe treated vines, thinned until cluster closer stage. There was a positive linear correlation ( $R^2 = 0,92$ ) noticed between the sugar and the boron content of the juice of the Hárslevelű cultivar.

### *Wine quality*

Based on analytical and organoleptical results, the quality of the wine was improved by the cluster thinning. In 2004, by the effect of the thinning, the sugar and acid free extract content of the wine was 20% higher than same of the untreated ones. At the same year the quality scores of wine of the thinned vines reached 1,8 points more, than those of the control ones. The effect of the time and severity of the treatments on the quality of the wine were more moderate than expected.

### *The modifying factors of the effect of the thinning*

The meteorologically different years had meaningful influence on the recorded parameters of the experiment.

However, as a result of the experiments it can be stated that the results of the Furmint and Hárslevelű do not differ from each other only in absolute values, but even their reactions to the effects of the thinning were of different scale, in some cases even of different directions, although these cultivars were grown on the same plot, on the same plantation structure and they are in close taxonomical relation.

### *New scientific achievements*

1. Based on the results of the investigation the severe fruit thinning leaving one cluster and carried out between berry set and cluster closer phenological stage (from mid June to end of July) was favourable for the vegetative growth of the Furmint and the Hárslevelű cultivar. In that case the pruning weight and the diameter of the 5<sup>th</sup> internode was even 40% greater than the control in some cases. Moreover, in case of the severe thinning completed until cluster close, the sugar, the  $\alpha$  amino nitrogen, the total free amino acid, the arginin, the total element, the potassium, the magnesium, the calcium, the phosphorus, the boron contents of the juice, in addition to the quality scores of the wine, were the highest. At the same time the yield of the roots treated as mentioned was reduced by 10% less than it was calculated from the reduction of the clusters number.

2. By the effect of the thinning completed between berry set and cluster closer, the Y/P ratio has also decreased even, if the yield has not changed significantly. In three years average, due to the thinning there was a close to 50% decrease of the Y/P ratio, which led to the optimization of the balance of the vegetative and reproductive organs. Greater sugar content of the juice was noticed by the effect of the higher proportion of the vegetative organs. The increase of the sugar content of the juice exceeded an average of 8% compared to the control.
3. According to my results the determination of the peroxidase and the polyphenol oxidase enzyme activity and phenol content of the cane could be a suitable method to follow the stress impact of the vines during the dormant period. The peroxidase and the polyphenol oxidase enzyme activity of the cane of the thinned vines were 50% lower than the control in case of the Hárslevelű cultivar.
4. Similarly to the  $\alpha$  amino nitrogen, the total assimilable nitrogen content in the juice of the thinned vines was approximately 10% higher than that of the unthinned ones. The  $\alpha$  amino nitrogen in the juice of the Furmint and the Hárslevelű cultivars was mainly determined by the quantity of the arginin. The juice of the severe treated vines thinned between berry set and cluster closer stage had the highest arginin content.
5. The total element, the potassium, the magnesium, the calcium, the phosphorus and the boron content of the juice of the Furmint cultivar increased considerably by the severity and decreased by the later date of the thinning. The juice of the severe treated vines, thinned until cluster closer stage contained approximately 100% more magnesium, calcium and phosphorus content than the juice of the control ones. There was a significant positive linear correlation registered between the sugar and the boron content of the juice of the examined cultivars.
6. Based on the results of my experiment a different sensitivity for cropping of the Furmint and the Hárslevelű cultivars was concluded. The vines of the Hárslevelű cultivar presented a satisfactory vegetative growth, even in case of high crop load. In 2004 the pruning weight was a satisfactory 3,1 tons/ha at yield of

26,3 tons/ha. The Y/P ratio remained under 10, indicating that the ratio of the vegetative and the reproductive organs of the vines did not reach the critical value. Meanwhile moderate effect of the thinning was recorded on numerous indices. The sugar content of the juice proved to be the most apparent, whereas the juice of the severe treated, early thinned vines was only 1,5 Ref% greater than the control.

The Furmint cultivar turned out to be more sensitive to crop load than the Hárslevelű. In the good 2004 the untreated Furmint vines produced 26,3 tons fruit/hectare, while only 1,4 tons/hectare pruning weight was recorded. The Y/P ratio of the control vines was an average of 15,6, which presents that the vines were highly overcropped. The balance between the vegetative and the reproductive organs was optimized by cluster thinning, which also presented in the higher sugar content of the juice. In 2004 soluble solid content of the severe treated vines, thinned at cluster closer was 25% higher than that of the control ones.

### Conclusions and suggestions

However the vegetative growth was stimulated by the thinning treatment, but crowded, dense canopy was not observed as a result of the early and severe thinning. The size of the leaf area and the pruning weight were mainly determined by the meteorological conditions of the year. The practice of the canopy management (number of trimming) is chiefly depending on the factor of the year.

The severity of the thinning should be stipulated as cluster/shoot or cluster/bearing unit, if the vines are royat cordon trained and the base buds of the cultivar are fertile. In this manner the number of the clusters per vine could be correctly forecasted and the outcome is independent of the year and the cultivar.

However low (3,3 bud/m<sup>2</sup>) bud load and also low (10-12 shoot/vine) shoot load is obtained, the Furmint and the Hárslevelű have the potential to produce three times higher yield (26 tons/hectare in recent study) from a year to another, with negative effects on numerous characteristics of the vine. In certain years the yield reduction of the vines of the two major cultivars of Tokaj wine region is essential within the vegetation period. The

cluster thinning could be a suitable method to achieve the balance between the vegetative and the reproductive organs of the vine.

Based on the vegetative growth, the biochemical measurements of the cane, the examined parameters of the fruit and wine quality of the examined cultivars, the cluster thinning is advised to be performed between berry set and cluster closer stage (from mid June to end of July).

The Y/P ratio of the untreated vines of the Furmint cultivar was highly over than the critical value of 10. In case of Furmint the optimization of the balance between the vegetative and the generative organs can be obtained by applying severe thinning to one cluster in certain years. In this manner the quality of the juice and wine and the vegetative performance of the root will increase with the decreasing number of clusters remained on the vines.

Based on the results of the experiment, in case of the vines of Hárslevelű cultivar the light thinning, leaving one cluster/shoot could be successfully utilized. The value of the pruning weight of the control vines was satisfactory (3,1 tons/ hectare), even if the yield was 26,1 tons/hectare. The Y/P ratio was not greater than 8,5 during the three years of the research. Although high yield was recorded, the assimilate supply of the clusters was still decent. The sugar content of the juice increased moderately with the decreasing number of clusters remained.

### References

- AMATI, A., MARANGONI, B., ZIRONI, R., GRAZIANI, N., CASTELLARI, M., ARFELLI, G. (1994): *Prove di vendemmia differenziata. Effetti del diradamento dei grappoli sui parametri vegeto-produttivi (Nota II).* Riv. Vitic. Enol., 47 (2) 13-24. p.
- BÉNYEI F., LŐRINCZ A. (2005): *Borszőlőfajták, csemegeszőlő-fajták és alanyok. Fajtaismeret és -használat. Mezőgazda Kiadó. Budapest.*
- BÉNYEI F., LŐRINCZ A., SZ. NAGY L. (1999): *Szőlőtermesztés. Mezőgazda Kiadó. Budapest.*
- BRAVDO, B., HEPNER, Y., LOINGER, C., COHEN, S., TABACKMAN, H. (1984): *Effect of crop level on growth, yield and wine quality of a high yielding Carignan vineyard. Am. J. Enol. Vitic., 35 (4) 247-252. p.*
- BRAVDO, B., HEPNER, Y., LOINGER, C., COHEN, S., TABACKMAN, H. (1985a): *Effect of crop level and crop load on growth, yield must and wine*

- composition and quality of Cabernet sauvignon. *Am. J. Enol. Vitic.* 36 (2) 125-131. p.
- BRAVDO, B., HEPNER, Y., LOINGER, C., COHEN, S., TABACKMAN, H. (1985b): Effect of irrigation and crop level on growth, yield, must and wine quality of Cabernet Sauvignon. *Am. J. Enol. Vitic.*, 36 (2) 132-139. p.
- CARBONNEAU, A. (1996): General relationship within the whole-plant: examples of the influence of vigour status, crop load and canopy exposure on the sink „berry maturation” for the grapevine. (Proceedings of Strategies to Optimize Wine Grape Quality, 1996, Conegliano, Italy). *ISHS Acta Horticulturæ*, 427 99-118. p.
- CARBONNEAU, A., LECLAIR, P., DUMARTIN, P., CORDEAU, J., ROUSSEL, C. (1977): Etude de l' influence chez la vigne du rapport partie vegetative parti productrice sur la production e la qualite des raisins. *Conn. Vigne Vin.*, 2 105-130. p.
- CORDNER, C. W., OUGH, C. S., KASIMATIS, N. A., KISSLER, J. J. (1978): Effect of crop level on the chemical composition and headspace volatiles of Lodi Zinfandel grapes and wines. *Am. J. Enol. Vitic.*, 29 (4) 247-253. p.
- CSEPREGI P. (1992): A szőlőültetvények fitotechnikai mutatói. I. rész. A mutatók meghatározásához végzett adatfelvételezések módszertani fejlesztése. *Magyar Szőlő- és Borgazdaság*, 2 (1) 2-5. p.
- DUKES, B. C., BUTZKE C. E. (1998): Rapid determination of primary amino acids in grape juice using an o-Phthaldialdehyde/N-Acetyl-L-Cysteine spectrophotometric assay. *Am. J. Enol. Vitic.*, 49 (2) 125-134. p.
- EDSON, C. E., HOWELL, G. S., FLORE J. A. (1993): Influence of crop load on photosynthesis and dry matter partitioning of Seyval grapevines. I. Single leaf and whole vine response pre- and post-harvest. *Am. J. Enol. Vitic.*, 44 (2) 139-147. p.
- FERREE, D. C., CAHOON, G. A., SCURLOCK, D. M., BROWN, M. V. (2002): Effect of time of cluster thinning grapevines. *Small Fruits Review*, 2 (1) 3-14. p.
- FERREE, D. C., SCURLOCK, D. M., STEINER, T., GALLANDER, J. (2004): 'Chambourcin' grapevine response to crop level and canopy shade at bloom. *J. Amer. Pom. Soc.*, 58 (3) 135-141. p.
- FISCHER, K. H., BRADT, O. A., WIEBE, J., DIRKS, V. A. (1977): Cluster thinning „de Chaunac” French hybrid grapes improves vine vigor and fruit quality in Ontario. *J. Am. Soc. Hortic. Sci.*, 2 162-165. p.
- HEPNER, Y., BRAVDO, B. (1985): Effect of crop level and drip irrigation scheduling on the potassium status of Cabernet sauvignon and Carignane vines and its influence on must and wine composition and quality. *Am. J. Enol. Vitic.*, 36 (2) 140-147. p.
- JEN, J. J., KAHLER, K. R. (1974): Characterization of polyphenol oxidase in peaches grown in the southeast. *Hort. Sci.*, 9 (3) 590-594. p.
- KLIEWER, M. W., DOKOOZLIAN, N. K. (2005): Leaf area/crop weight ratio of grapevines: influence on fruit composition and wine quality. *Am. J. Enol. Vitic.*, 56 (2) 170-181. p.
- MÁJER J., GYÖRFFYNÉ JAHNKE G. (2005): Autochton szőlőfajták optimális termesztéstechnológiáját megalapozó kísérletek eredményei Badacsonyban. *Borászati Füzetek (Kutatás)*, 15 (2) 4-9. p.
- MILLER, D. P., HOWELL, G. S., FLORE, J. A. (1997): Influence of shoot number and crop load on potted Chambourcin grapevines. II: Whole-vine vs. single-leaf photosynthesis. *Vitis*, 36 (3) 109-114. p.
- MORRIS, J. R., MAIN, G. L., OSWALD, O. L. (2004): Flower cluster and shoot thinning for crop control in French-American hybrid grapes. *Am. J. Enol. Vitic.*, 55 (4) 423-426. p.
- OUGH, C. S., NAGAOKA, R. (1984): Effect of cluster thinning and vineyard yields on grape and wine composition and wine quality of Cabernet sauvignon. *Am. J. Enol. Vitic.*, 35 (1) 30-34. p.
- PONI, S., LAKSO, A. N., TURNER, J. R., MELIOUS, R. E. (1994): Interactions of crop level and late season water stress on growth and physiology of field-grown Concord grapevines. *Am. J. Enol. Vitic.*, 45 (2) 252-258. p.
- REYNOLDS, A. G., YERLE, S., WATSON, B. T., PRICE, S. F., WARDLE, D. A. (1996): Fruit environment and crop level effects on Pinot noir. III. Composition and descriptive analysis of Oregon and British Columbia wines. *Am. J. Enol. Vitic.*, 47 (3) 329-339. p.
- SHANNON, L. M., KAY, E. LEW, J. Y. (1966): Peroxidase isozymes from horseradish roots. I. isolation and physical properties. *J. Biol. Chem.*, 241 (9) 2166-2172. p.
- SINGLETON, V. L., ROSSI, J. A., Jr. (1965): Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *Am. J. Enol. Vitic.*, 16 (3) 144-158.
- SMITHYMAN, R. P., HOWELL, G. S., MILLER, D. P. (1998): The use of competition for carbohydrates among vegetative and reproductive sinks to reduce fruit set and botrytis bunch rot in Seyval blanc grapevines. *Am. J. Enol. Vitic.*, 49 (2) 163-170. p.
- STERGIOS, B. G., HOWELL, G. S. (1977): Effects of defoliation, trellis height and cropping stress on the cold hardiness of Concord grapevines. *Am. J. Enol. Vitic.*, 28 (1) 34-42. p.
- WERNER J., LŐRINCZ A. (2002): A Sauvignon blanc rügy- és fűrterhelésének a termésmennyiségre és a minőségre gyakorolt hatásai. *Borászati Füzetek (Kutatás)*, 12 (1) 5-8. p.
- WINKLER, A. J., COOK, J. A., KLIEWER, W. M., LIDER, L. A. (1974): *General Viticulture*. California Press. Berkley.



## List of publications

### Articles in published in Journal:

- BALOGH I. – TÓTHNÉ SURÁNYI K. – **LUKÁCSY GY.** (2002): A talaj káliumtartalmának alakulása egy észak-magyarországi szőlőültetvényben (The constellation of the potassium content of the soil in a vineyard of northern Hungary). *Kertgazdaság* 34, 4: 18-24. p.
- BARÓCSI, Z. – BALOGH, I. – KÁLLAI, M. – **LUKÁCSY GY.** (2001): The effect of bud density on the composition of colour in red wines. *International Journal of Horticultural Science*, 7, 3-4: 63-68. p.
- BÉNYEI, F. - LŐRINCZ, A.– GÁCSI, T. – **LUKÁCSY, GY.** (2003): The Results of the Cross breeding of the Department of Viticulture. *Proc. VIII<sup>th</sup> International Congress on Grape*, 26-31 August 2002, Kecskemét – Hungary, *Acta Horticulturae* 603, ISHS, Volume 2, 697-699. p.
- FAZEKAS I. – ZANATHY G. – LŐRINCZ A. – **LUKÁCSY GY.** (2006): A szőlő termésritkítás néhány újabb módszerének értékelése (The examination of some new method of yield regulation). *Kertgazdaság* (megjelenés alatt).
- FAZEKAS I. - ZANATHY G. - LŐRINCZ A. - BARÓCSI Z. - **LUKÁCSY GY.** (2006): A fürttépés hatása a szőlő teljesítményére. *Borászati Füzetek (Kutatás)*, 16 (4), 6-9. p.
- LŐRINCZ A. – **LUKÁCSY GY.** – ZANATHY G. (2003): A fűrtrikítás hatása a szőlő teljesítményére I. A nemzetközi szakirodalom áttekintése. *Borászati Füzetek (Kutatás)*, 13, 1: 1-10. p.
- LUKÁCSY GY.** – BALOGH I. – LŐRINCZ A. (2003): A fűrtrikítás hatása az érésmenetre a 2003-as évjáratban Tokaj-Hegyalján. *Borászati Füzetek (Kutatás)*, 13, 5: 5-10. p.
- LUKÁCSY GY.** – BARÓCSI Z.- HERCZEG P. – SÁROSSY E. – BALOGH I. – FAZEKAS I. - LŐRINCZ A.– ZANATHY G. (2003): A fűrtrikítás hatása a szőlő teljesítményére II. A Szőlészeti Tanszéken az elmúlt évtizedben végzett fűrtrikítási kísérletek eredményei. *Borászati Füzetek, (Kutatás)*, 13, 2: 1-10. p.
- LUKÁCSY GY.** – LŐRINCZ A. - ZANATHY G. (2002): A rügyterhelés hatása a Zweigelt fajta teljesítményére. *Borászati Füzetek (Kutatás)*, 12, 3: 1-6. p.
- LUKÁCSY GY.** – STEFANOVITSNÉ BÁNYAI É. – VARGA ZS. BALOGH I. (2006): The effect of the timing of the fruti thinning on the magnesium content of the juice and the wine of the Furmint and the Hárslevelű cultivars in Tokaj. *Abstracts, Magnesium Research*, 19 (1): 70-81. p.

## Conference proceedings:

Hunraian, full paper:

- LUKÁCSY GY.** (2002): A Zweigelt fajta rügyterhelés vizsgálata egyesfüggöny művelésen (Investigation of budload of Zweigelt variety on single curtain training system). III. Alföldi Tudományos Tájégzaldkódási Napok Kiadványa, 2. kötet, 77-82. p.
- LUKÁCSY GY.** – BALOGH, I. – ZANATHY, G. - KOVÁCS, T. (2003): A fűrtrikítás szerepe az integrált szőlőtermesztésben Tokaj-Hegyalja példáján. Integrált kertészeti termesztés, SZAB Kertészeti Munkabizottságának tudományos ülése, Szarvas, 2003. október 17. 263-268. p.
- LUKÁCSY GY.** – SIMONNÉ SARKADI L. - STEFANOVITSNÉ BÁNYAI É. – KOVÁCS T. -BALOGH ISTVÁN SÁNDOR (2005): A fűrtrikítás hatása a must szabad aminosavtartalmának alakulására Tokaj-Hegyalján. Erdei Ferenc III. Tudományos konferencia „A vidék jövőéért, a jövő vidékéért” (2005. augusztus 23-2. Kecskemét). II. kötet, 704-708. p.
- LUKÁCSY GY.** – STEFANOVITSNÉ BÁNYAI É. – FAZEKAS ISTVÁN – BALOGH ISTVÁN SÁNDOR (2004): A fűrtrikítás idejének és mértékének hatása a Furmint fajta mustjának és borának mikroelem összetételére. *Proceedings, Szeged 11th Symposium on Analytical and Environmental Problems (Szeged, SZAB 27 th September 2004)*, 212-216. p.
- LUKÁCSY GY.** – STEFANOVITSNÉ BÁNYAI É. – FAZEKAS ISTVÁN – KOVÁCS T. -BALOGH ISTVÁN SÁNDOR (2005): A terméskorlátozás hatása a vessző peroxidáz enzim aktivitására. Erdei Ferenc III. Tudományos konferencia „A vidék jövőéért, a jövő vidékéért” (2005. augusztus 23-2. Kecskemét). II. kötet, 709-713. p.
- LUKÁCSY GY.** – STEFANOVITSNÉ BÁNYAI É. – ZANATHY G. – BALOGH I. S. (2005): A must és a bor kalcium- és magnéziumtartalmának alakulása a fűrtrterhelés függvényében. *Proceedings, Szeged 12th Symposium on Analytical and Environmental Problems (Szeged, SZAB 26 th September 2005)*. 395-399. p.
- TÓTHNÉ SURÁNYI K. – BALOGH I. – **LUKÁCSY GY.** (2003): A magnézium ellátás szerepe néhány magyarországi borvidéken (The role of the Mg supply in some vine growing regions of Hungary). Integrált kertészeti termesztés, SZAB Kertészeti Munkabizottságának tudományos ülése, Szarvas, 2003. október 17. 175-180. p.
- ZANATHY G. – FAZEKAS I. –LŐRINCZ A. – **LUKÁCSY GY.** (2006): A szürkerothadás mérséklése terméskorlátozó zöldmunkákkal. Integrált termesztés a kertészeti és szántóföldi kultúrákban XXVII. (megjelenés alatt).

Hungarian, abstract:

- BÉNYEI F. – LŐRINCZ A. - **LUKÁCSY GY.** – ULCZ A. (2005): A rügyterhelés hatása a Kékfrankos és Olaszrizling fajták termésének mennyiségére és minőségére (The effect of the bud load on the yield and the quality of the Kékfrankos and the Wlsh rizling cultivars). Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak 2005. október 19-21., Budapest, 298-299. p.
- BÉNYEI F. – LŐRINCZ A. - **LUKÁCSY GY.** – ZANATHY G. – FAZEKAS I. (2005): Fitotechnológiai eljárás hatása a termés minőségére (The effect of the fitotechnical operation on the quality of the grape). Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak 2005. október 19-21., Budapest, 300-301. p.
- LUKÁCSY GY.** (2002): A rügyterhelés hatása a Zweigelt fajta fitotechnikai mutatóinak alakulására (The effect of the bud load on the fitotechnical parameters of Zweigelt variety). XLIV. Georgikon Napok, Stabilitás és Intézményrendszer az Agrárgazdaságban Tudományos Konferencia Kiadványa, 64. p.
- LUKÁCSY GY.** – BALOGH I.(2003): Összefüggés a fűrtválogatás időpontja és a Furmint – Hárslevelű tőkék mennyiségi – minőségi mutatói között Tokaj-Hegyalján (The relationship between the timing of fruit thinning and quantitative and qualitative indexes of the vines of the Furmint, Hárslevelű varieties (*Vitis vinifera* L.) in Tokaj-Hegyalja). Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak 2003. november 6-7., Budapest, 522-523. p.
- LUKÁCSY GY.** – BALOGH I. (2003): A fűrtvitkítás mértékének hatása a Furmint és a Hárslevelű fajták teljesítményére Tokaj-Hegyalján (The effect of the severity of the fruitthinning on the productivity of Furmint and Hárslevelű (*Vitis vinifera* L.) in Tokaj-Hegyalja). Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak 2003. november 6-7., Budapest, 524-525. p.
- LUKÁCSY GY.** – GÁCSI T. – ZANATHY G. – LŐRINCZ A. – BÉNYEI F. (2005): A rezisztencia nemesítés eredményei a Corvinus Egyetem Szőlészeti Tanszékén. XI. Növénynevelési Tudományos Napok 2005. március 3-4. Összefoglalók, 108. p.
- LUKÁCSY GY.** –KOVÁCS T. - BALOGH I.(2005): A fűrtvitkítás idejének és mértékének a Furmint és a Hárslevelű fajták generatív teljesítményére Tokaj-Hegyalján (The effect of the time and the severity of fruit thinning on the generative performance of Furmint and Hárslevelű (*Vitis vinifera* L.) cultivars in Tokaj-Hegyalja). Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak 2005. október 19-21., Budapest, 278-279. p.
- LUKÁCSY GY.** –STEFANOVITS-BÁNYAI É. – FAZEKAS I. - KOVÁCS T. - BALOGH I.(2005): A peroxidáz enzim aktivitásának alakulása a fűrtvitkítással kezelt tőkék levelében (Changes of peroxidase enzyme activity in the leaf of the vine treated with fruit thinning). Lippay János –

Ormos Imre – Vas Károly Tudományos Ülésszak 2005. október 19-21., Budapest, 320-321. p.

- LUKÁCSY GY.** – STEFANOVITSNÉ BÁNYAI É. – VARGA ZS. – BALOGH I. (2005): A fűrtvitkítás idejének hatása a Furmint és a Hárslevelű mustjának és borának Mg-tartalmára Tokaj-Hegyalján. 9. Magyar Magnézium Szimpózium 2005. május 19-20 Eger. Program és összefoglalók 13-14. p.
- LUKÁCSY GY.** –ZANATHY G. - KOVÁCS T. - BALOGH I.(2005): A termésszabályzás hatása a szőlőtőkék vegetatív teljesítményére (The effect of the fruit thinning on the vegetativ production of the vine). Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak 2005. október 19-21., Budapest, 322-323. p.
- SÁRDI É. – TORDAI E. – **LUKÁCSY GY.** – STEFANOVITS-BÁNYAI É. – BALOGH I. (2006): A termőfajta és a fűrtvitkítás hatása a szőlőbogyók glükóz/fruktóz arányának alakulására Tokaj-Hegyalján. XI. Növénynevelési Tudományos Napok 2006. március 7-8. Összefoglalók, 144. p.
- TÓTHNÉ SURÁNYI K. – BALOGH I. – **LUKÁCSY GY.** (2003): A magnézium ellátás szerepe néhány magyarországi szőlőtermesztő tájon (The role of the Mg supply in some vine growing regions of Hungary). 8. Magyar Magnézium Szimpózium 2003. május 29-30. Hajdúszoboszló, 27-29. p.

International full paper:

- LUKÁCSY, GY.** - *STEFANOVITS-BÁNYAI, E. - BALOGH, I. (2004): Metal elements in the juice and the wine of the cultivar Furmint and Hárslevelű grown in Tokaj. Proceedings of the 6 th International Symposium on Metal Elements in Environment, Medicine and Biology (Timisoara, November 8-10, 2004), Tome VI., 299-302. p.*
- LUKÁCSY, GY.** - STEFANOVITS-BÁNYAI, E. – HEGEDŰS, A. - BALOGH, I. (2006): Changes of the mineral element composition of the grape juice with the application of yield regulation in the vineyard practice. Proceedings of the International Symposium on Trace Elements in the Food Chain (Budapest, May 25-27., 2006.), 241-245. p.
- LUKÁCSY GY.,** BALOGH I., BÉNYEI F., FAZEKAS I., KÁLLAI T., LŐRINCZ A., ZANATHY G. (2006): The effect of the crop management on the vegetative and the generative performance of the Furmint and the Hárslevelű cultivars in Tokaj Wine Region. XXIXth World Congress of Vine and Wine OIV 2006 Spain, Logroño 25-30 June, CD-Rom (full paper).

International (abstract):

- LUKACSY GY.** - STEFANOVITS-BÁNYAI E. – SIMON-SARKADI L. —  
BALOGH I. (2005): Evaluation of the free amino acid and the primary amino nitrogen content of the juice and the wine of the Furmint and the Hárslevelű cultivars in Tokaj wine region. In *Vino Analytica Scientia*, Montpellier, July 7-9. 2005. Abstract Book, 92. p.
- SÁRDI É. – STEFANOVITS-BÁNYAI E. – TORDAI E. –  
**LUKACSY GY.** – BALOGH I. (2005): Evaluation of the glucose and the fructose content of the grape juice utilizing Overpressured Layer Chromatographic (OPLC) separation method. In *Vino Analytica Scientia*, Montpellier, July 7-9. 2005. Abstract book, 91. p.
- ZANATHY, G. – **LUKÁCSY, GY.** – BARÓCSI, Z. – FAZEKAS, I. (2003): Die Wirkung von Laubfläche auf dem Botrytisbefall der Rebe (c.v. Palatina) in Versuchen auf dem Standort Szigetcsép. 4. Symposium Phytomedizin und Pflanzenschutz im Gartenbau. 22. – 25. September 2003. Wien 169-170.p.