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# DIFFERENTIATION OF WINEGRAPE MATURITY AND OF MUST CONTENTS OF EARLY AND LATE RIPENING WHITE GRAPEVINE VARIETIES UNDER MINIMAL PRUNING CONDITIONS

## DIFFÉRENCIATION DE LA MATURITÉ DES GRAPPES ET DES SUBSTANCES DU MOÛT DANS LES CEPAGES BLANCHES D'UNE MATURITÉ PRÉCOCE ET TARDIVE SOUS LES CONDITIONS D'UNE CONDUITE DE TAILLE MINIMALE

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### **Abstract :**

Under cooler climate conditions the winegrape maturity is the central point of wine quality. Minimal pruning training systems (MP) developed in Australia with the objective to produce high quality wines at low cost input were investigated in Germany since 1995. General problems of minimal pruning such as high crop load, delayed grape maturity and lower wine quality were observed. Experimental data during six years with the early ripening grapevine varieties Bacchus and Müller-Thurgau in Franconia showed the possibility to produce basic quality wines at low cost level. Later ripening varieties such as Silvaner reached incomplete maturity and lower wine quality. The excessive vegetative growth of MP, expressed in 3 to 8 times larger leaf area per vine, changes the growth physiology. Therefore the energy input during the last ripening weeks creates the final grape quality and is demonstrable by the amino acid Prolin in must, which can serve as indicator for the year-specific maturity level. In comparison to cane pruned trellis training system (CPT) the minimal pruning system presented a delay of 5-15 days in grape maturity depending on the yearly conditions. Because of better health conditions the delay in maturity of early ripening varieties can be compensated in MP systems by later harvest times. The late ripening variety Silvaner can not equalize this maturity delay and offers more vegetative flavours in wine caused by the incomplete grape maturity. In cooler years the wines of Silvaner showed the tendency to develop untypical ageing off-flavours (UTA). The stronger vegetative flavours in wines of MP plots are reflected in the significantly higher amount of the sulphur containing amino acids in must. Opposite to maturity, must of minimal pruned vines was nearly always significantly higher in yeast assimilable nitrogen which seems to be correlated with the higher vigour and leaf area of the MP system.

**Key words :** Grapevine, minimal pruning, LAI, grape maturity, prolin content in must, YAN in must

**Résumé :** Dans les climats viticoles tempérés le degré de la maturité des raisins détermine la qualité du vin. En Australie, le système de conduite de taille minimale (MP) était développé avec l'objectif de réduire les dépenses de la production des grappes. Depuis 1993 ce système de conduite est analysé aussi en Allemagne. Les problèmes principaux de MP sont le rendement des grappes trop haut, la maturité retardée des grappes et une qualité inférieure du vin. Les recherches en Franconie avec MP pendant les dernières six années avec deux cépages précoces comme Bacchus et Müller-Thurgau montrent la possibilité de produire des vins de base avec ce système d'une conduite moins cher. D'autre part, un cépage plus tardif comme le Silvaner atteint une maturité incomplète et le vin est d'une qualité inférieure. En comparaison avec le système de conduite en espalier (CPT) la croissance forte du MP système change complètement la physiologie de la vigne que se reflète dans sa surface foliaire de 3 jusque 6 fois plus haute. L'alimentation en énergie solaire pendant les dernières semaines de la période de la maturation détermine la maturité finale des grappes que se reflète dans la concentration du Prolin dans le moût. Cela montre, que Prolin pourrait servir comme indicateur de la maturité des grappes influencé des conditions climatiques de l'année. En comparaison avec le système de conduite espalier, le système de conduite de taille minimale montre un retard dans la maturité de 5 à 15 jours dépendant de l'année et du cépage utilisée. A cause de la structure des grappes peu cohérentes dans le système à MP il y a une meilleure santé des raisins que signifie que le retardement de la maturité des variétés précoces peut être partiellement compensé pour une récolte plus tard. Les cépages tardifs comme Silvaner ne peuvent pas compenser la maturité plus tard. En conséquence ils montrent une quantité élevée des arômes végétatives. Dans les années plus froides le système MP avec Silvaner montre une tendance de développer le vieillissement atypique (UTA) dans le vin. Contrairement à la maturité des grappes, la part des acides aminés utilisable pour les levures (YAN) était significativement plus haute dans le système de conduite de taille minimale que dans le système d'espalier, attribuant à la vigueur de la croissance e au haut index de la surface foliaire.

**Mots clés :** *Vitis vinifera*, taille minimale, acide aminé, prolin, maturité de grappe, YAN en moût

## INTRODUCTION

Since 1975 Minimal Pruning (MP) was developed in Australia as a new training system to lower the cost of winegrape production (Clingleffer, 1978). Clingleffer (1992) reported that more than 65 % of Australian winegrape vineyards were pruned mechanically with a more or less intensity. Investigations with MP in different winegrowing regions were successful and led to the first experiments with Riesling in the Rhine valley in Germany in 1993 (Schultz et al. 1999b).

First experiments with Riesling were successful, but high crop load, crop load alternation and insufficient maturity of grapes were problems to be resolved (Schultz et al. 1999b, Schwab and Nüsslein, 2002). Wines of MP vineyards were fresh, fruity and with higher vegetative flavours than the CPT wines. The vigour of the MP plots was higher without symptoms of drought damage during short dry periods. Since 1999 Minimal Pruning was also investigated in the winegrowing region of Franconia situated in the north-eastern part of Bavaria along the river Main.

Under cooler climatic conditions, the degree of maturity of grapes is the critical point of the resulting wine quality (Schwab, 2001). The objectives under these climatic conditions were to investigate the use of Minimal Pruning with different winegrape varieties and to analyse the influence of this new training system on must and wine quality. The Prolin content in must serves as a maturity indicator because under cooler climatic conditions Prolin is an enriched amino acid with correlation to insolation and the sugar accumulation in the last weeks of grape maturity (Schwab, 2001; Schwab et al. 2003a and 2003b). Kliewer (1971) already considered Prolin as a maturity indicator in ripening grapes.

## MATERIAL AND METHODS

The experimental data were obtained at 2 different locations: with the early ripening grape varieties **Müller-Thurgau** (Riesling x Madeleine royal) and **Bacchus** ((Riesling x Silvaner) x Müller-Thurgau) at a south-west oriented site in Leinach and with the late variety **Silvaner** (natural combination of Traminer x Austrian white) at a south exposed site in Erlabrunn (Table 1).

The vines were well developed, 8 to 12 years old and planted with a row-space of 3 meters. In 1999 the training system was changed from cane pruned trellis (CPT) to Minimal Pruning (MP) and their results compared. Vigour, blooming time, leaf area at veraison, crop load, must weight (°Oechsle), must content of acids, total nitrogen (Kjeldahl), minerals and amino acids (HPLC) were analysed. The grapes were harvested by hand and processed to must and wine under equal conditions. The fermentation in 100 l steel vessels was done with the same yeast strain under equal temperature conditions. After cross-flow filtration the wines were stored in 50 l balloon flasks and then filled in bottles with screw plug. The wines were tested twice by a professional tester panel of 10-12 testers.

## RESULTS

The 6 year means are listed in Table 1. The statistic computation between the **Minimal** (MP) and **Normal** (cane pruned trellis = CPT) training system shows significant differences for the variety **Bacchus** concerning the leaf area per vine, the leaf area index (LAI), the total nitrogen content in must, the content of the amino acids Arginin, Glutamin, Methionin and the yeast assimilable amino-nitrogen (YAN).

**Table 1**

Comparison of minimal and normal pruning for Bacchus, Müller-Thurgau and Silvaner. Mean values of 6 years (1999 – 2004) of harvest data, must content and wine valuation.

**Table 1**

Comparaison entre le système de conduite espalier et conduite de taille minimale des variétés Bacchus, Müller-Thurgau et Silvaner. Valeurs moyennes de 6 années de récolte (1999-2004), contenu du moût et évaluation sensorielle du vin.

parameters	varieties training system	Bacchus (1)		Müller-Thurgau (1)		Silvaner (2)	
		MP	CPT	MP	CPT	MP	CPT
yield kg/100 m <sup>2</sup>		154,3 a	141,7 a	150,5 a	133,7 a	297,6 a	96,6 b
must weight in °Oechsle		74,7 a	77,7 a	73,8 a	77,5 a	70,5 b	84,7 a
must acid g/l		6,2 a	6,4 a	5,8 a	7,00 a	9,0 a	7,2 b
leaf area m <sup>2</sup> /vine		13,9 a	4,3 b	14,4 a	4,0 b	36,0 a	4,5 b
leaf area index (LAI) m <sup>2</sup> /m <sup>2</sup>		5,79 a	1,79 b	6,00 a	1,67 b	9,60 a	1,20 b
leaf to fruit relation		2,54 a	0,91 b	3,40 a	0,91 b	2,19 a	0,95 a
total nitrogen in must mg/l		284 a	229 b	296 a	258 a	593 a	579 a
total amino acids in must in mg/l		1434 a	1043 a	1338 a	992 a	2203 a	2224 a
arginin in must in mg/l		402 a	238 b	370 a	259 a	969 a	1036 a
glutamin in must in mg/l		206 a	113 a	120 a	90 a	300 a	197 a
prolin in must in mg/l		106 a	134 a	187 a	137 a	49,6 a	114 a
methionin in must in mg/l		8,8 a	4,9 b	7,3 a	3,9 b	14,4 a	12,2 a
yeast assimilable amino nitrogen (YAN) mg/l must		276 a	181 b	231 a	167 a	514 a	514 a
residual extract in wine in g/l		8,35 a	6,90 b	5,30 a	3,92 a	7,94 a	8,13 a
sensoric valuation of wines (0-5 points)		1,86	1,8	2,01	1,9	1,63	1,47

Means with same letters are not significantly different at  $p < 0,05$ ; MP = minimal pruning; CPT = cane pruned trellis,

(1) site Leinach, SW-site, sandy loam soil, 25 % inclination, permanent green cover, rootstock 5 C

(2) site Erlabrunn, S-exposed, profound and humous sandy loam, 35 % inclination, autumn-winter green cover, rootstock 5 C

The residual extract in wine was significantly higher in the MP compared to the CPT training system. Together with the significantly higher Amino-N this result indicates the better uptake of minerals by the root tips. The differences in the first sensoric wine valuation were not significant. The significantly higher amino acid content in the must of Minimal pruned grapes, caused by higher Arginine and Glutamine values seems to be important. The lower maturity of the MP plots is expressed in the lower Prolin content. The loose structure of the grapes and a low susceptibility for botrytis in MP plots were obvious.

**Table 2**

Comparison of the ripening period from veraison to harvest between minimal(MP) and normal(CPT) pruned Bacchus, Müller-Thurgau and Silvaner in the year 2002 in relation to must weight and Prolin content at harvest.

**Table 2**

Comparaison de la période de la maturation à partir de la veraison à la récolte entre le système de conduite de taille minimale et de conduite espalier par Bacchus, Müller-Thurgau et Silvaner en relation avec la densité du moût (°Oechsle) et le contenu de proline

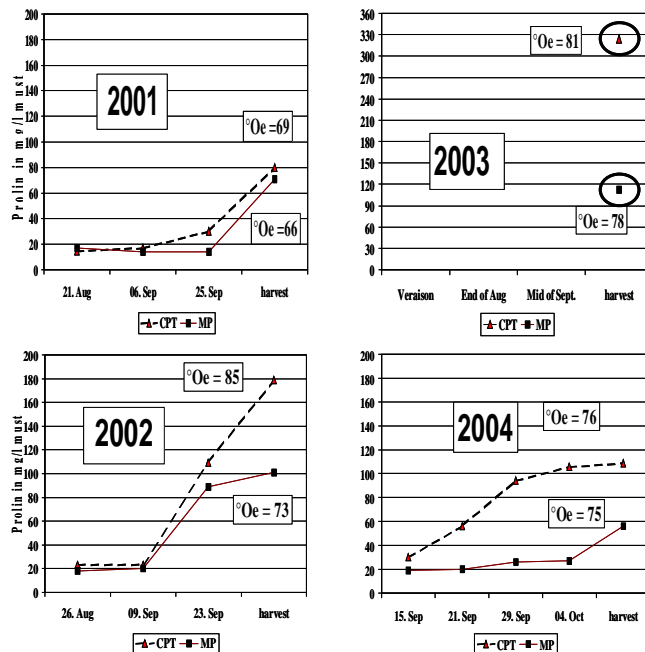
	Bacchus MP	Bacchus CPT	Müller- Thurgau MP	Müller- Thurgau CPT	Silvaner MP	Silvaner CPT
days from veraison to harvest in 2002	68	60	68	59	72	64
°Oechsle - at harvest	73	85	73	83	68	79
Prolin - content at harvest (mg/l must)	101	179	279	224	26	39*

\*) lower values because of chlorosis damage

The variety **Müller-Thurgau** showed similar reaction at a lower variance level. Only leaf area and the content of Methionin were significantly different. The yeast assimilable Amino-nitrogen (YAN), the Arginin and the total Amino acid content is apparently but not significantly higher in the MP than in the CPT plots. Compared to Bacchus the early ripening variety Müller-Thurgau reached higher Prolin values in the average which indicates a higher level of grape maturity. Residual extract and wine valuation were much better in Minimal than in CPT plots. The wines produced with Minimal Pruning were fresh, fruity and richer in vegetative flavours.

The late ripening variety **Silvaner** showed the highest increase of crop load and very high vigorous reactions under Minimal Pruning. The crop load was three times higher than in the CPT plots and therefore the must weight ( $^{\circ}\text{Oechsle}$ ) was significantly lower. The differences in leaf area are greater than for Bacchus or Müller-Thurgau and reached the highest LAI values. As caused by greater leaf area, nitrogen and amino acid content in must were not significantly lower in Minimal than in CPT plots.

Only the maturity indicator Prolin demonstrates very low concentrations and expresses the low grape maturity potential of the MP-wines (see Table 1). Yeast assimilable amino-nitrogen and residual extract in wine were higher than in Bacchus and Müller-Thurgau but not significantly between the pruning systems. The wine valuation however did not show any significant differences in the first valuation testing. After one year the Minimal pruned wines reached lower ratings in the second wine tasting and the untypical ageing off-flavour (UTA) was sensorically detectable.

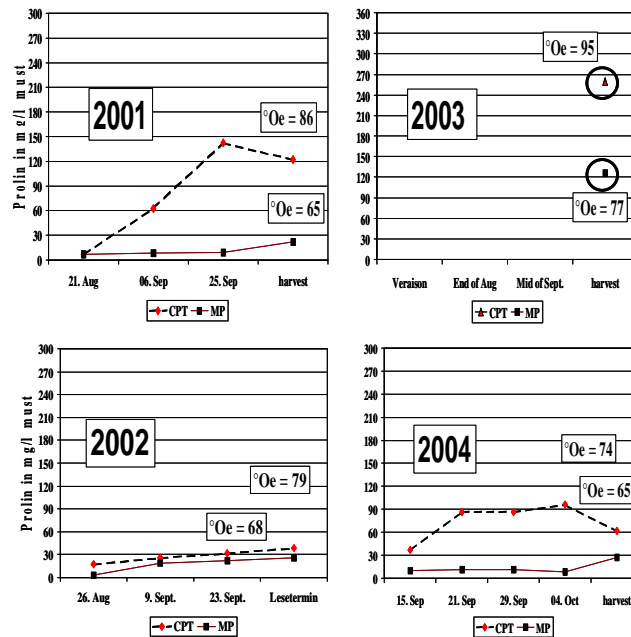


**Figure 1**  
Development of the prolin content in berry sap during 2001, 2002 and 2004 and the prolin content in must at harvest in all 4 years for the grapevine variety Bacchus compared with the must weight ( $^{\circ}\text{Oechsle}$ ) at harvest

**Figure 1**  
Développement du contenu de prolin dans le jus de raisins pendant des années 2001, 2002 et 2004 et du contenu de prolin dans le moût au temps de la récolte pendant toutes les 4 années pour la variété Bacchus en comparaison avec la densité du moût ( $^{\circ}\text{Oechsle}$ )

The ripening period from veraison to harvest was observed by 3 to 4 analysis of 100 berry samples. The amino acids of the berry sap were determined with HPLC analysis. In Table 2

the duration of the ripening period from veraison to harvest is presented for the climatically “normal” year of 2002. The delay in maturity and the prolonged ripening period of MP plots with a range of 8-12 days in 2002 is reflected in the lower must weight and prolin values respectively. The time between veraison and maturity depends on the year, the local climate and the health of the grapes. The early ripening varieties generally showed a shorter ripening period from veraison to maturity than Silvaner. A prolongation of the ripening phase by later harvest times does not seem to be useable to compensate the maturity delay for the late ripening Silvaner because of first frost events at the end of October.



**Figure 2**  
*Development of the prolin content in berry sap during 2001, 2002 and 2004 and the prolin content in must at harvest for the grapevine variety Silvaner compared with the must weight (°Oechsle) at harvest*

**Figure 2**  
*Développement du contenu de prolin dans le jus de raisins pendant des années 2001, 2002 et 2004 et du contenu de prolin dans le moût au temps de la récolte pendant toutes les 4 années pour la variété Silvaner en comparaison avec le densité du moût (°Oechsle)*

The Prolin accumulation in must during the ripening period indicates the lower maturity status of grapes in minimal pruning plots (see Figure 1). The early ripening variety Bacchus shows a clear differentiation in 3 of 4 years. The must weight (°Oechsle) at harvest does not express these year-specific maturity differences. In the wine tastings the stronger expression of vegetative flavours of the MP plots was apparently higher and seems to be correlated with the higher amount of sulfur containing amino acids. Methionine is significantly higher in the MP plots of Bacchus and Müller-Thurgau (Table 1). The development of Prolin in grapes of the early ripening grapevine variety Müller-Thurgau is similar to Bacchus but at a higher level (Tab. 1). The increase of the Prolin content in the berry sap during the last 3-4 weeks of ripening starts when the sugar accumulation has reached a value of around 60° Oechsle. The late ripening variety Silvaner shows a different accumulation of prolin compared with Bacchus and Müller-Thurgau. The Prolin content in the must of MP plots is very low, caused by high crop load and late ripening varietal determination.

Figure 2 shows the low accumulation of Prolin in normal years as 2002 and 2004. In the very hot and dry year 2003 the prolin content reached higher amounts at harvest. The decrease of

prolin in 2001 and 2004 in the CPT plots is caused by the attack of botrytis and a loss of amino acids.

## DISCUSSION

To reduce production cost Minimal Pruning as a new training system is actually tested in several regions of Germany. Problems such as high crop load, crop load alternation, lower maturity level of the grapes and a lower wine quality have been observed (Schultz et al.1999b, Bauer 2002, Molitor 2003, Schwab and Nüsslein 2002 and 2005, Wohlfarth 2005).

High crop load of MP plots is a general problem in wet and cooler regions (Smart and Robinson, 1991). Excessive yield depresses the grape maturity and finally the wine quality.

The results with the late ripening variety Silvaner confirm the worldwide experiences that minimal pruning seems to be more recommended for early ripening varieties under yield controlled conditions.

In almost yield balanced plots as shown for Bacchus and Müller-Thurgau the energy input during the last ripening weeks is the limiting factor of must and wine quality (see Figure 1). MP plots with higher crop loads as found for example for Silvaner showed a very low reaction in Prolin accumulation during the last ripening weeks (Fig.2). Late ripening varieties with high crop load often do not reach an acceptable maturity status in must so that the wines are marked by UTA flavours. Wohlfarth (2005) recorded that MP is not recommended for the later ripening variety Pinot gris because of lower maturity and higher damage caused by botrytis but that early ripening variety Müller-Thurgau can be advised.

Werwitzke (2003) found remarkable differences in grape maturity for Riesling. Molitor (2003) observed a year specific maturity delay for Müller-Thurgau in the Mosel valley, Wohlfarth (2005) found a maturity delay for Pinot gris till to 4 weeks and Sommer (1995) described a delay in maturity for Shiraz in Australia too.. The results in this study confirm the delay of 5 to 15 days in grape maturity by using MP. Under cool climate conditions the compensation of lower maturity by means of the prolongation of the ripening phase is often not usable for late ripening varieties because of first frost events at the end of October.

Considering the wine quality, early ripening varieties as Bacchus and Müller-Thurgau have shown higher quality than the late ripening variety Silvaner. Generally, wines of MP grown plots were described as thinner, more fruity and with more vegetative flavours (Schultz et al. (1999b), Schwab and Nüsslein (2002), Hill et al. (2000)). Werwitzke (2003) pointed out, that berries of MP plots of Riesling contain higher bound aromatic flavours measured by glycosyl-glucose assay (GG's) than berries of grapes grown under cane pruned trellis system. Schultz et al. (1999a) recorded, that the higher content of GG's may result from the lower berry size of MP grapes. According to Rapp and Versini (1996) one part of the higher flavour in MP plots seems to be caused also by the higher amount of amino acids in must of Bacchus and Müller-Thurgau. Increased amounts of minerals and amino acids in musts of MP plots were observed by Clingeffer (1999) too.

The early ripening varieties as Bacchus and Müller-Thurgau grown under MP reached mostly a acceptable level for a basic wine quality with fruity flavours. Yield regulation during flowering or post-flowering seems to be necessary to avoid excessive crop load and low wine quality in MP plots.

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