# VINEYARD MANAGEMENT, FRUIT RIPENING AND FLAVOR DEVELOPMENT

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There are many factors in vineyard establishment and management that influence fruit ripening and flavor development. In many cases the big challenge is to distinguish between the effects the multitude of interacting parameters have on fruit ripening and flavor formation. For instance, high radiation levels on the fruit, irrespectively of how those are achieved, are always coupled to higher fruit temperatures, thus making it impossible to relate the impact on fruit composition to one factor alone. Since many metabolic processes are light saturated, yet have distinct temperature optima, the same light level may have substantially different effects on grape composition, depending on the prevailing temperature (Coombe 1987). This is important to keep in mind when considering canopy systems and canopy management for example as tools for improving grape quality, while moving from one climatic region to the next or changing varieties.

## Elements that influence ripening and flavor

Fortunately, we do know most elements which can have an influence on the flavor of wine grapes that are vineyard based. Unfortunately, the system is obviously extremely complex, so that with some exceptions, our understanding of the system in changing climatic situations from year to year, preclude to repeat these elements and use them as a prescription for future success in the production of good white wine grapes with absolute certainty.

When a vineyard is planted, several variables available to the viticulturist to manipulate flavor may be considered fixed. These are the genetic make up of the vines, the rootstock selected and the environment of the vineyard. The latter can't be changed and makes up the site characteristics. Within a variety such as Riesling, the genetic variability associated with clonal variation seems to be rather limited and it is difficult to ascertain any qualitative differences with the exception of a certain deviation of some clones from the general sugar concentration to yield relationship (Schaeffer 1984).

As with rootstocks, there is a strong interaction with soil type, soil pH, water availability, climate and scion cultivar, which makes the optimal choice a difficult one. In general, only riparia x berlandieri – type rootstocks (SO4, 5BB, 125AA, 5C) are currently used in Germany with the exception of some new phylloxera resistant types, such as Boerner (*Vitis cinerea*). However, with the appearance of more frequent drought years in the 90$^{s}$, some discussion on the use of drought hardy rootstocks such as the rupestris x berlandieri crossings 110R, 140 Ruggieri or 1103 Paulsen has started. The problem with these rootstocks is, that they are very vigorous once there is sufficient water, leading to high malic acid levels and increased incidence of botrytis. In dry years, however, we have observed higher sugar levels at comparable yields with Riesling for 110R as compared to 125AA and improvements in wine flavor.

Another influence on flavor that may be considered is the design of the vineyard. Whereas the effect of row orientation is less clear (Champagnol 1984), there is evidence that planting density can have a substantial effect on ripening and flavor development. In an experiment with Riesling planted on 5C rootstock in 1978 at 2m row distance but varying within row spacing at 0.6, 1.2, 1.8, and 2.4m at equal bud load per ha, little long-term effects on yield were observed. However, slightly higher sugar levels were apparent for the high density plantings and large differences in amino acid concentration in the juice were noted (Fig. 1). The latter resulted in improved fermentation with positive effects on the fruity characters of the resulting wine.

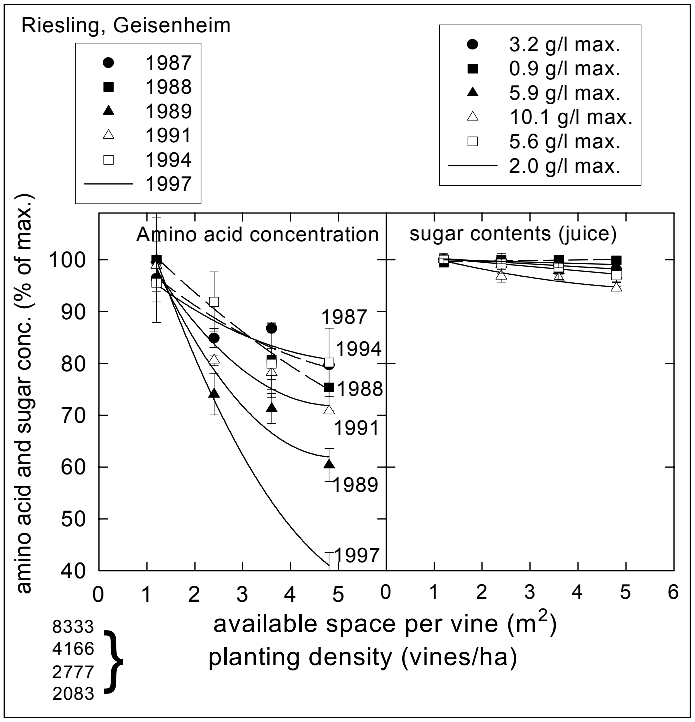


*Fig. 1: Effect of planting density on amino acid and sugar concentration in Riesling juice over several vintages. Between row spacing was 2m. In-between row spacing varied from 0.6m to 2.4m max. Maximum differences in sugar contents (g/L) are indicated in the legend.*

The choice of the canopy system can influence fruit ripening and flavor development of Riesling as has been shown by Reynolds et al. (1994) in Canada. With white grapes, however, the effects are less clear than with red varieties, mainly because for reds there is a clear relationship between color and phenolics formation and light exposure, but a high phenolic content may not be beneficial for wine quality in whites. The largest effects on cluster structure, fruit ripening and grape composition of Riesling have been observed in experiments with minimal pruning systems (Schultz et al. 2000). Apart from the higher production potential, which in a quality strategy should be judged detrimental, several traits have appeared which point to a large potential for high quality fruit production of these systems in cool climates. Clusters become less tight and thus less prone to botrytis infection. Berry size is reduced leading to higher skin to pulp ratios with the potential for increased flavor concentration (Kraml 1998). Glycosidically bound secondary metabolite content (G-G's) including aroma components, is higher in berries from minimal pruning (MP) than from conventional vertical shoot positioned (VSP) systems, irrespectively of the vintage (Fig. 2).

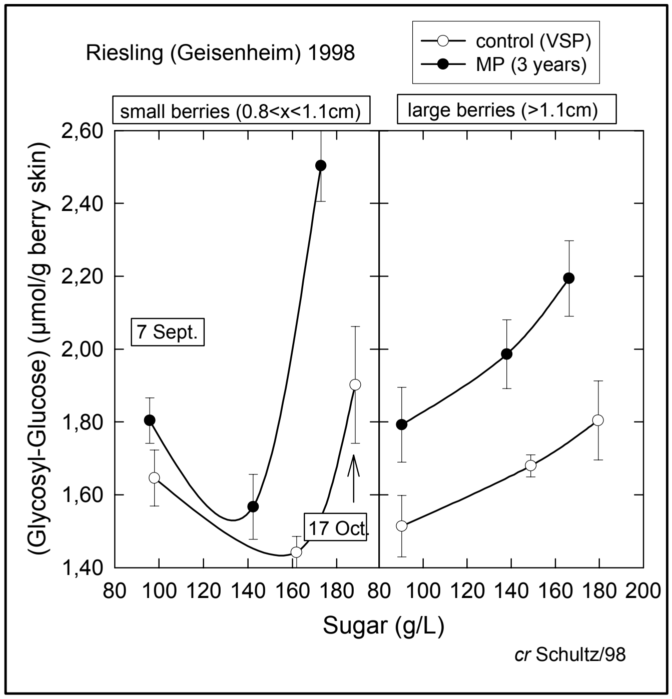


*Fig. 2. Effect of the canopy system on the concentration of total glycoconjugates in the berry skin of small and large berries of Riesling grapes during ripening in 1998 (adapted from Schultz et al. 2000).*

Sugar concentration is normally less in MP systems due to higher yields but when this difference is eliminated by the addition of sucrose before fermentation, Riesling wines from MP systems are generally judged superior to wines from VSP systems The remaining problem to solve here is to control yield without disturbing the balance of the vine.

Varying fertilizer input will alter flavor by indirect means such as increasing shoot growth and as a result to that malic acid concentration (Champagnol 1984). It seems that N fertilization is essential to maintain quality in white varieties and to avoid the formation of off-flavors such as atypical aging (ATA).

Many authors report that canopy manipulation will alter the flavor of wine grapes, among these results are also some on Riesling (Reynolds et al. 1994, Reynolds et al. 1996, Schultz et al. 1999). Leaf removal in the fruiting zone for instance, primarily done to reduce disease, has been found to increase the G-G concentration in the fruit (Zoecklein et al. 1998, Schultz et al. 1999), yet it did not improve the sensory attributes of the wine (Schultz et al. 1999). In fact for Riesling, the contribution of the basal leaves to sugar loading of the fruit can be substantial (up to 2.3 °Brix), and the reallocation of nitrogen out of the basal leaves into the fruit is obviously reduced when these leaves are removed. This may be one reason for reduced amino acid concentrations of the fruit from vines where leaves had been removed to improve fruit zone micro-climate. Shoot topping will influence flavor development primarily through it's effect on yield. The later the date of hedging after full bloom, the higher the sugar concentration and the lower the yield (Huegelschaeffer 19990). Since sugar concentration is at least to some extend coupled to flavor formation, improved grape composition can be expected.

Crop manipulation either by pruning level or cluster thinning will influence fruit ripening and flavor formation. In Riesling, early cluster thinning (approximately 3 weeks after bloom), can significantly improve secondary metabolite content in the fruit and sensory performance of the wines (Schultz et al.

2000). The success of this management tool, however, strongly depends on crop load, thus the leaf area to fruit ratio, and berry size and cluster compactness. In this respect, early thinning will lead to more compact clusters and larger berries with increased danger of botrytis formation.

In recent years, several experiments have been conducted with reflecting foils underneath the canopy. These foils reflect solar radiation back into the fruiting zone and have been used with the intention to improve color formation in red varieties (Igounet et al. 1995). However, Riesling grapes showed a marked improvement in flavor development as a response to this treatment over several years without substantial differences in sugar levels. The mechanisms of this improved aroma formation are unclear, but probably related to the altered light spectra impinging on the fruit.

Perhaps the most readily apparent influence on flavor over which we may have some control is harvest date. There are considerable changes in composition that occur through the period of ripening even in the absence of significant changes in sugar concentration. Among the most prominent are increases in aromatic precursors (Bauer 1997), amino acids and decreases in malic acid. The increase in the amino acid proline, which can not be used by yeast in fermentation, has long been proposed as ripening indicator (Du Plessis 1984). To find the optimum harvest date, however, is still very much a challenge to viticulturists and enologists alike, since regional, climatical and management influences may change fruit composition at similar sugar contents and thus alter the optimum date of harvest.

**Literature**

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