Characterization of vineyard sites for quality wine production using meteorological, soil chemical and physical data.

D. HOPPMANN[1],K. SCHALLER[2]

[1] *Agrarmeteorologische Beratungs- und Forschungsstelle des Deutschen Wetterdienstes, Kreuzweg 21, D-65366 Geisenheim, Deutschland*

[2] *Forschungsanstalt Geisenheim, Institut für Biologie, Fachgebiet Bodenkunde und Pflanzenernährung, Postfach 1154, D-65358 Geisenheim, Deutschland*

1. INTRODUCTION

The quality of grapevines measured by yield and must density in the northern part of Europe - conditions can be characterized as a type of "cool climate" - vary strongly from year to year and from one production site to another, i.e. differences in must densities can range from 30 to 50 °Oe. An explanation may be changes of weather conditons during critical developmental stages of the grapevines (2, 3, 5). These can be categorized as "macro climatic" influences. According to them different grape growing areas can be discriminated ; nothern viticultural areas show a distinct yearly variation in must quality than the southern ones. The second scaling deals with spatial and timely variability in a growing region, i.e. topography, soil type and climate. The influences of both categories on must quality will be described subsequently.

2. MACROCLIMATIC INFLUENCES

As well as the quality also the onset of the different phenological stages grapevines pass, varies from year to year. Therefore the growing season is divided in stages which are most important for growth and performance and to relate them to the prevailing weather conditons. An analysis reveals 6 relevant and significant developmental stages. Guideline was the German scheme consisting of 23 stages (1). The three main developmental stages "bud break - full bloom", "full bloom - veraison", "veraison - harvest" are divided in two additional subphases, finally resulting in 6 stages. Weather conditions are related to the six developmental stages for the period from 1947 - 1984. Calculation were made with the help of a linear regression with must density as dependant and the weather conditions as independant variables. The following variables were used for the calculations : (a) a variety specific and weighed optimum curve for the temperature maximum ; (b) direct solar radiation ; (c) precipitation ; (d)saturation deficit ; (e) climatic water balance

The main share of quality formation is in the stage "full bloom" with 46 %, followed by temperatures during berry growth before veraison with 16 %. The climatic water balance in combination with the saturation deficit in stage 3, which represents the most rapid growth period of berries, and the climatic water balance in stage 5, influence must density with 10 %. During the following ripening period temperatures and solar radiation are responsible for 8 % of the must density formation. These findings do not offer any information about importance and direction of the variables. Those are listed in table 1. It can be seen that an eight days earlier bloom increases at least the must density for 6 °Oe ; a 1 °C increase of temperature in stage 4 has a similar influence, and an increase of the daily solar radiation income of 160 Joule/cm^2 combined with a temperature increase of 1.9 °C, raises the must density for 7 °Oe.

Also a sufficient water supply in stage 3 (saturation deficit and climatic water balance) increases the must density. In contrast rainfall during the ripening period reduces quality expectations.

Tableau 1. Effect of different variables on the changes of must quality (°Oe) of cv. Riesling
[Postulated variation range : +1 standard deviation]

Variable	Variation range	Influence on must density (°Oe)
Full bloom	+ 8 days later	- 6.2
Maximum temperature in phase 4	+ 1 °C	+ 6.2
Water Balance,	+ 1. mm/d	
Saturation deficit in phase 3	+ 3.9 hPA/d	+ 8.7
Rainfall in phase 6	+ 0.96 mm/d	- 4.6
Solar Radiation	+ 162 Joule/d	
Maximum temperature in phase 6	+ 1.87 °C	+ 7.4
Rainfall	+ 0.71 mm/d	
Water balance in phase 5	+ 1.24 mm/d	- 1.9

Phase 3 = Phenological stage 23 (full bloom) - stage 29 (pea sized berries)

Phase 4 = Phenological stage 29 (pea sized berries) - stage 35 (veraison)

Phase 5+6 = Phenological stage 35 (veraison) - stage 38 (ready for picking)

During stage 5 the influence of this factor is of minor importance : - 2 °Oe occurs through an increase of the water balance of 2 mm/d. In the stage before harvest raising the water balance for 1 mm/d reduces the must density by 5 °Oe. With an average duration of 20 days in this phenological stage a total 20 mm of rain is achieved. Otherwise it is not possible during the analyses of this time series to detect relationships between yield and quality.

3. MACROCLIMATIC INFLUENCES

In northern grape growing areas an important influence on the quality besides the yearly weather conditions results as well from the spatial variables and their timely distribution. These were investigated since 1960 on 125 test plots. A direct measurement of the mesoclimate was not possible on all locations, therefore the discrimination of the sites against each other is made with variables derived from calculation models. The following variables are used for this process : (a) direct solar radiation income (KJoule/cm^2) ; (b) temperatures during night and day dependant from exposition and ; (c) height above sea level ; (d) cold air exposition is available for every location in a special map.

Methods are described by Hoppmann (4). Similar to the above mentioned analyses performed for the years, also in this case the thermic conditions are most important for the quality. Integral part of these methods is the calculation of the energy income from the direct solar radiation during the growing season from April to October. Nomogrammes and computer programmes are available for the calculations (4).

For example a northern orientated plot with an inclination of 10° receives less 37 KJoule/cm^2 x growing season from direct solar radiation than a comparable south orientated one. This results in an average of ten years in a difference in must density of roughly 10 °Oe. Tab. 2 elucidates exemplarily these relationships.

Tableau 2. Influence of site parameters on must density (°Oe) in cv. Riesling (10 years average)

slope exposition	slope inclination	height a.s.l.	must density (°Oe)	Td*
SE	20	245	71	13.6
SE	04	218 (windy site)	61	12.8
SW	07	211	73	13.7
S	18	170	77	14.3
S	23	145	83	14.5
S	03	110 (cold air)	67	13.4

*Td = average temperature daily phase during ripening

The plot with an inclination of 23° to south and a height of 145 m a.s.l. has in a ten years average a must density of 83 °Oe by an average daily temperature of 14,5°C during the ripening stage. In the site 100 m higher a.s.l. temperature is 0.9 °C lower and as a consequence must density lowers to 71 °Oe (- 12 °Oe) in a ten years average. A higher wind exposition or cold air reduces the temperature and (as a strict consequence) the must densities.

Radiation and temperature can be merged and described with the help of an empirical method, plotting the temperature decrease with height a.s.l. against falling energy income. In a multifactorial analysis with ten years means it was tried to elucidate the influence of different et climatic and pedological parameters on must density and acidity.

4. PEDOLOGICAL PARAMETERS

Tabl. 3 indicates clearly that in flat - slightly sloped areas roughly 35 % of the variability of must density is determined by the solar radiation income, 5 % by the height a.s.l. and additional 5 % from cold air influences. The variables i.e. plant available water, soil type and trunk height are neglectable. In steep slopes, which are characteristic for great parts of German viticulture, the height a.s.l. determines with 41 % the must quality, followed by plant available water with 8%, and at least the solar radiation with 6 %.

The relationships (table not shown) between must acidity and site parameters in flat areas are the same but with an inverse influence. The interrelationship between height a.s.l. and solar radiation is obvious.

Tableau 3. Influence of pedological and plant parameters on must quality in differing sites. Contribution (%) for the explanation of the variabilty of must density.
(10 years average 1964-74)

Site characteristic	independant variable	% contribution (R^2 x 100)
flat	_ rad. (Apr - Oct)	35.8
	altitude a.s.l.	3.9
	cold air	6.5
steep	altitude a.s.l.	39.9
	plant avail water	10.6
	_ rad. (Apr - Oct)	6.3

The influence of pedological factors is demonstrated with the results from 1973, a year with a relatively dry growing period (tabl. 4). It can be seen that plant available water determines 37 % of the must density variability ; followed by soil C content (13,6 %). Both variables claim for 50 % of the total quality buildup.

In contrast, in the flat-slightly sloped areas more or less soil nutrient factors are dominating with magnesium, nitrogen and C/N ratio. Plant available water ranks in an inferior place.

Tableau 4. Influence of pedological parameters on the must quality in differing sites in 1973. Contribution (%) for the explanation of the variabilty of must density

Site characteristic	independant variable	% contribution (R^2 x 100)
flat	Mg (subsoil)	10.8
	soil type	7.4
	N % (topsoil)	6.7
steep	plant available water	36.6
	C % (topsoil)	13.6

The overall influence of soil factors is demonstrated in calculations made with the means of ten years (tabl. 5). In steep sites, one can see that roughly 3 parameters dominate the quality formation, i.e. available phosphorus in top and subsoil and total nitrogen, which is also a (indirect) measure of organic matter. All together are responsible for 40 % of the quality formation. In the flat-slightly sloped areas also available P in the subsoil as well as potassium in top and subsoil determine 32 % of the quality. Soils in flat-slightly sloped sites are mainly loamy, so it is convincing that the potassium availability has a particular inportance.

Tableau 5. Influence of pedological parameters on the must quality in differing sites. Mean of ten years. Contribution (%) for the explanation of the variabilty of must density (ten years average 1964-74)

Site characteristic	independant variable	% contribution (R^2 x 100)
flat	P (subsoil)	22.1
	K (subsoil)	3.2
	K (topsoil)	7.3
steep	P (subsoil)	20.6
	N % (topsoil)	15.1
	P (topsoil)	5.3

5. SYNOPTIC COMBINATION OF MESOCLIMATIC AND PEDOLOGICAL INFORMATIONS

The experiences about mesoclimatic and pedological influences on quality of musts can be combined in "synthetic maps". In the Rheingau region for more than 40 years soils are mapped in a scale of 1:5000 (6). With the additional informations about meso- and macroclimatic influcences on quality formation, maps can be constructed which show the influence of solar radiation, temperature and soil on a distinct production site. Fig 1 shows a part of such a map, scale 1:5000. The results of soil mapping, mesoclimatic model calculations and the means of ten years yield and must quality measurements are merged in this synoptic map. In the legends detailed information is given about soils, soil types and recommendations for the choose of different rootstocks (fig. 1a). Two small general maps show the borderlines of vineyards sites and expected growing periods (fig. not shown).

6. CONCLUSION

Long-term investigations in the Rheingau region demonstrate very clearly, that the quality buildup in grapevine production in northern European areas is strongly dominated by the solar radiation income and the temperature regime as well in the macroclimatic as in the mesoclimatic scale. Detailed information combined with these findings allow the quantitative construction of maps demonstrating the influence of the production sites. Problems of water availability are not important under "cool climate" conditions, but may be play a route in the "mediterranean" climate and can be used for a classification of those production sites. But on the other hand it may be pointed out, that in very dry years "water" may be become also important under "cool climate" conditions. These relationships shown for different years, may indicate that drought production sites, i.e. in mediterranean areas, emphasis may shift from temperature to soil water budgets. The actual and available information basis allows to develop for those regions well suited climatic and soil maps. The interelationships between grapevine and soil are not so absolutely elucidated, as those between quality formation and climatic conditions.

As could be demonstrated for a ten year average principally more or less heavy available nutrients seem to influence the quality formation in grapevines. On a one year scale different parameters, mainly ready available nutrients are indicated to influence the quality build up. It is also interesting that these soil parameters can only explain _ 40% of the variability of must density and never reach the same importance as the climatic parameters.

7. REFERENCES

1. EICHHORN K.W.,LORENZ H.K.(1977). Phänologische Entwicklungsstadien der Rebe. Seperate from *"Der Deutsche Weinbau" Heft 1.*

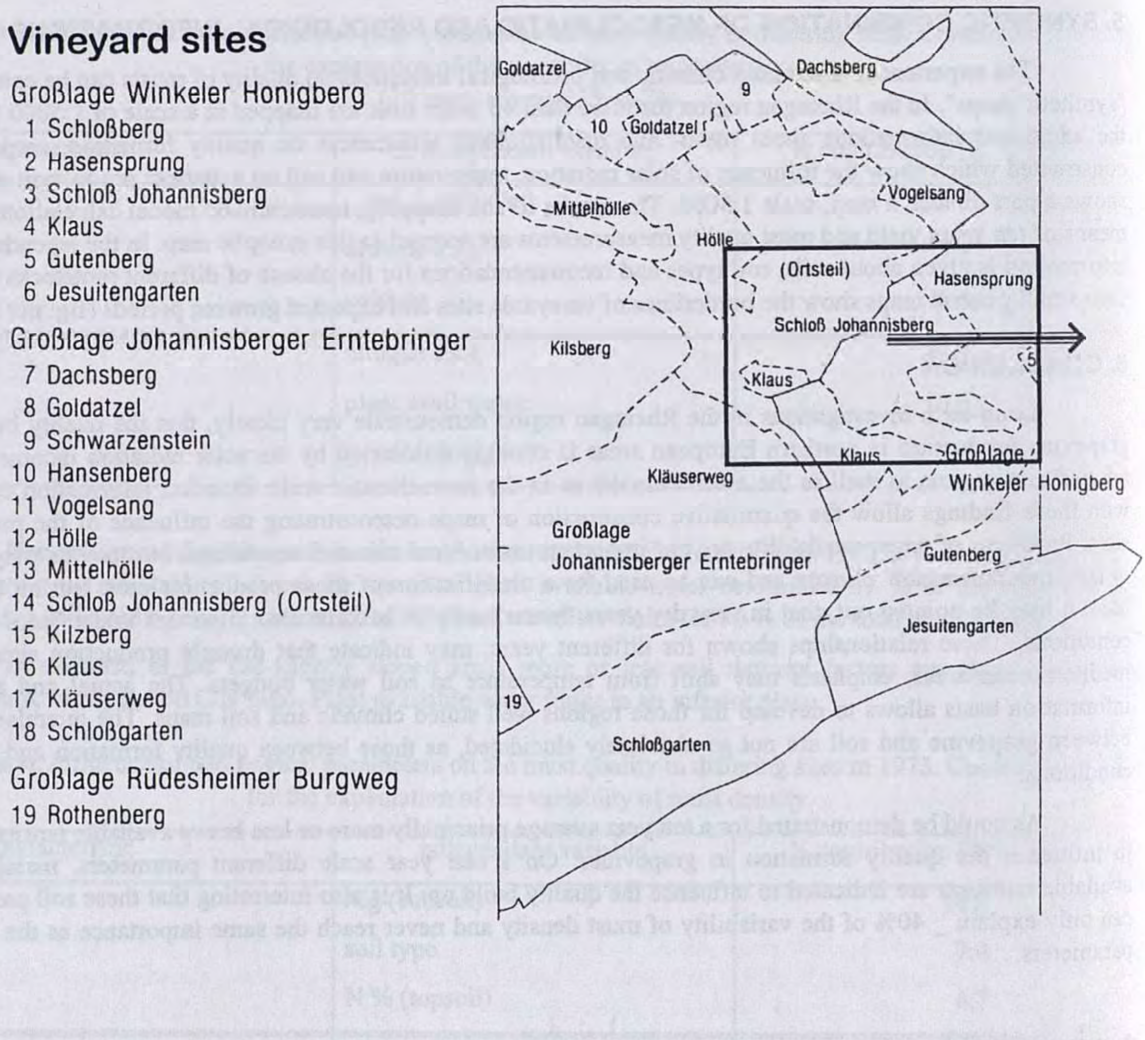
2. HOPPMANN D., SCHALLER K.(1981). Influence of different site parameters on quality and quantity of grapevines. *1. Part: Weinwissenschaft 36, 299-319*

3. HOPPMANN D.,SCHALLER K. (1981). Influence of different site parameters on quality and quantity of grapevines. *2. Part: Weinwissenschaft 36, 371-377*

4. HOPPMANN D. (1988). Der Einfluß von Jahreswitterung und Standort auf die Mostgewichte der Rebsorten Riesling und Müller-Thurgau (*Vitis vinifera* L.). *Berichte des Deutschen Wetterdienstes Nr. 176. Offenbach*

5. KOBLET W.,ZWICKY P. (1965). Der Einfluß von Ertrag, Temperatur und Sonnenstunden auf die Qualität der Trauben. *Weinwissenschaft 20, 237-244*

6. ZAKOSEK H.,BECKER H. (1979). Einführung in die Weinbau-Standortkarte Rheingau im Maßstab 1:5000. *Geologisches Jahrbuch Hessen 107, 261-281*



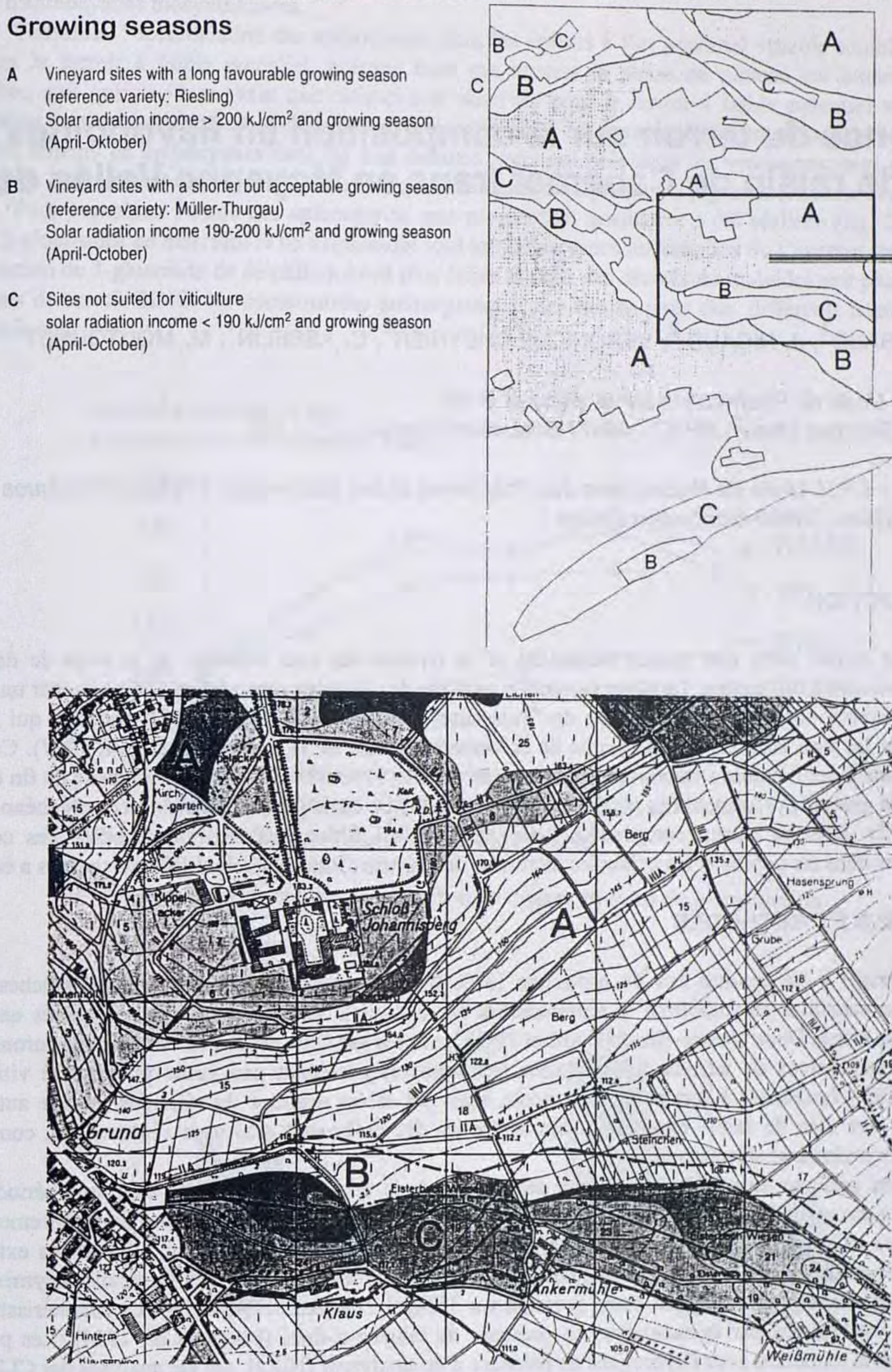


Figure 1. Part of the synoptic map Johannisberg (scale 1:5000). Different gry scales indicate different soil types with varying geological origin (6). [see appendix]

Besides the soil classification 3 climatic zones for grapevines are developed : (a) zone A = locations with a long climatic favourable growing season (recommended varieties Riesling, Pinot noir) ; (b) zone B = locations with a reduced climatic growing season (recommended variety Müller-Thurgau) ; (c) zone C = not suited for grapevine growing