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Grapevine Varieties and Site Conditions in the Viticultutral Regions of Hesse

1. Introduction

The Geisenheim Research Centre has played a pivotal role in grapevine breeding and grafting in the winegrowing areas of Hesse, since the founding of the breeding section there in 1890. The first trial vineyards with grafted grapevines were established in the Rheingau wine-growing region in the 19th century. Since then, the Rheingau has benefited directly from the research carried out at Geisenheim. Later grafting and cultivation experiments were limited to a few rootstock varieties from the so-called Prussian Assortment. In the meantime, these varieties have become a mainstay in viticulture.

Then as now, research has focused on creating high quality grapevines using grafting techniques. The new Berlandieri x Riparia types originally created by TELEKI at the end of the 1920s replaced the older Riparia-Rupestris-Vinifera rootstock variety. However, until after WWII the most important varieties were Aramon x Riparia 143 A and 26 G (Trollinger x Riparia) developed in Geisenheim. Because of their low Pylloxera tolerance, these varieties were eliminated in the following decades and almost completely replaced with the more tolerant variety Berlandieri x Riparia. The clones of this variety are of particular interest in viticulture and today they dominate the rootstock market. The classification of the new rootstock variety Börner in 1991 introduced the first Phylloxera resistant rootstock to viticulture.

The widespread introduction of grafting into viticultural practice was accompanied by efforts to improve the scions. The state of Hesse and especially the Rheingau wine-growing region were at the forefront of clone development especially of the Riesling variety. The pioneering efforts of the state winery administration and the clones developed by the Institute for Grapevine Breeding and Grafting at Geisenheim were the key to the successful and profitable introduction of the Riesling grape. Riesling is the main variety cultivated in Hesse and represents the regional character. Many other noble grape varieties are also grown in Hesse. The high latitude of the German wine growing regions has forced grape growers to make the best use of the potential of the sites. Climate and soil have a decisive effect on wine quality. The profitability of our vineyards is determined by selecting the best suited rootstock for the grape variety grown on a specific location.

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2. The grafted grapevine in its entirety

The aboveground parts of a grafted vine are genetically completely different from that of the underground part. Therefore any consideration of site specific factors must take into account the physiological demands of the rootstock as well as the scion. Both components together form the grafted vine and each part has a certain influence on the other. This interaction depends on the site-specific conditions. For example, it is not possible to combat lime-induced chlorosis in a scion by changing the rootstock. A lime-sensitive scion will keep this individual property even if the rootstock is capable of overcoming this site-specific problem. Yet, the rootstock does have an effect on the scion, but only within the physiological limits of the scion or clone. Practical grapevine cultivation involves balancing the internal, genetically fixed reciprocal effect between rootstock and scion with the modifying influence of the site factors to ensure the highest possible gain from the vine.

Discussions concerning the selection of rootstocks often take a one-sided view of adaptation or soil suitability. Our rootstocks do not adapt to specific site factors, but behave according to their intrinsic physiological limits. For example warmth –loving rootstocks will never adapt to cooler locations. The current perception of adaptation is a holistic concept of rootstock and scion tolerance for specific site conditions. The rigid notion of adaptation in viticulture, which was the result of the 19th century biological world-view, is no longer acceptable today. How can one speak of "poor adaptation" of the Kober 5BB variety when this vigorous rootstock induces reduced fruit set in the scion if planted too closely? One could actually speak of the opposite of "poor adaptation" under these circumstances, since Kober 5BB is responding positively to the given site conditions. However, this has a negative effect on the scion. In this situation, the unfortunate term "site affinity" is no better a term than "adaptation".

Older trials with different rootstocks have demonstrated the superiority of less-vigorous varieties. However, modern vineyard management practices such as mechanization and cover cropping actually favor the more vigorous rootstocks. These facts have little to do with the outdated concept of "adaptation". The grafted grapevine comprises the scion and the rootstock which have a mutual effect on each other. The scion is primarily affected by the microclimatic conditions. The rootstock may also be influenced by this factor – we know of rootstocks especially suited to warm sites.

The rootstock is mainly affected by soil conditions. The soil also has an indirect effect on the scion, which can be detected in the wine. All rootstocks should be tolerant or, better still, resistant against all Phylloxera species. If this is not the case then Phylloxera species can be a decisive factor for example in European x American crossings. A typical example of this is the rootstock variety 26 Geisenheim (Trollinger x Riparia), where the production losses due to an infection depend on the Phylloxera type. Especially virulent types can infect any of our common rootstock varieties with the exception of Börner. As a rule however, an infection will have little effect on production.

Organic matter supply and fertilization are especially important for grafted grapevines. Many difficulties can be avoided by a sufficient supply of organic matter, which has an overall positive effect on grafted grapevines.

Planting density and training have a profound effect on the grafted vine. Pruning level has a profound effect on grape quality and quantity. Figure 1 summarizes the holistic factors affecting grafted grapevine production. The arrows indicate the direction and intensity of the effect.

These interactions must be taken into consideration when discussing rootstock

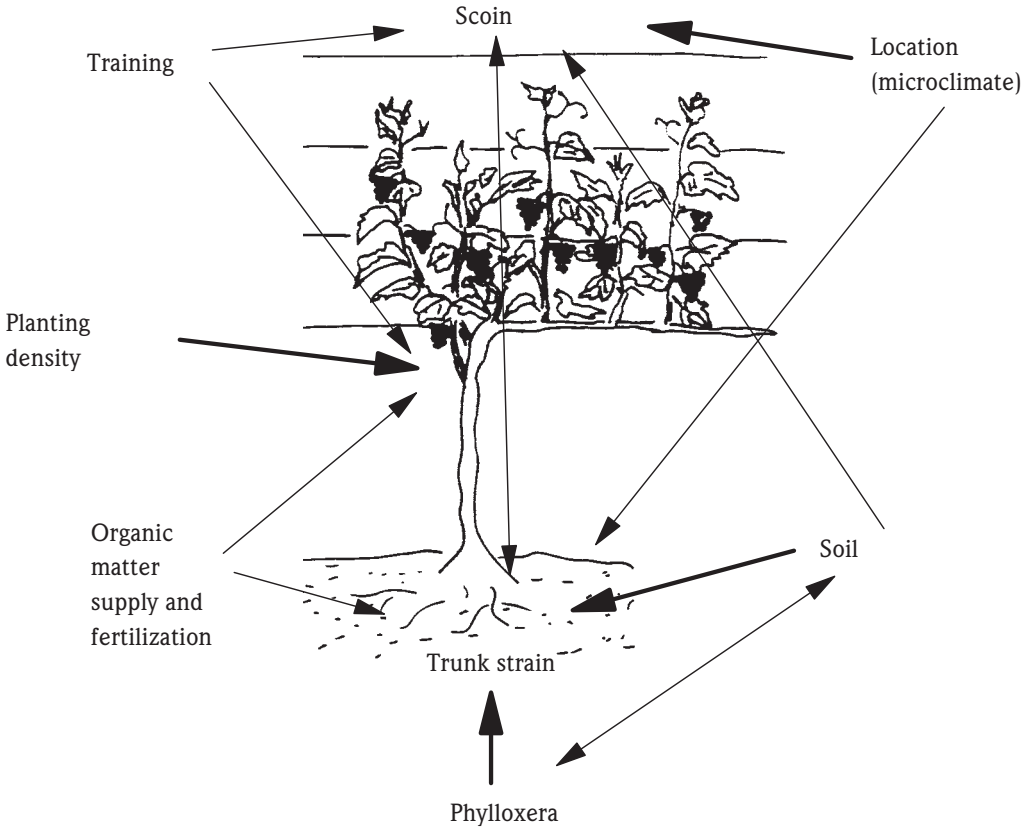

Fig. 1. Illustration of the factors affecting grafted grapevine production and their mode of action.

selection and site conditions. In general, the problems associated with the specific site conditions of the wine-growing areas in Hesse, have been resolved holistically, taking into account the plant, climate and soil. In addition to this, adaptation trials have been carried out for wide range of rootstock varieties.

3. Grapevine varieties planted in the wine-growing regions of Hesse

The following sections describe the properties of the most important rootstock and scion varieties grown in Hesse.

3.1 The rootstocks

1. Kober 5BB (V. berlandieri x V. riparia)

This variety was selected by KOBER from the original Berlandieri x Riparia types bred by S. TELEKI. This rootstock tolerates up to 20 % free lime and induces vigorous scion growth. 5BB harmonizes with well-drained, light soils. On deep soils the rootstock can induce excessive vegetative growth in the scion, which can lead to reduced pigment production in red grapes, stem rot and botrytis bunch rot. These conditions can also lead to flower loss and reduced fruit set in high density plantations of varieties that are susceptible to coulure such as Gewürztraminer or Riesling.

In the meantime, several successful virus-tested subclones have been derived from the famous Kober 5BB clone 13 Geisenheim.

2. 5C Geisenheim (V. berlandieri x V. riparia)

The Geisenheim 6 and 10 clones of the 5C, first selected by BIRK from the sort originally developed by S. TELEKI have become exceedingly important in Riesling production. This lime-tolerant variety with moderate growth characteristics is especially suited for loamy, not too heavy soils. **5C Geisenheim** is less likely to induce coulure in sensitive sorts than Kober **5BB and grows more vigorously than** SO_4.

3. Teleki 4/Selektion Oppenheim (SO_4) (V. berlandieri x V. riparia)

Bred from Teleki 4, this variety has developed into one of the most important rootstocks used in Germany. **SO_4** tolerates up to 18 % free lime. On fertile soils, high density plantations of this rootstock paired with low vigor scions perform better than with **5BB. SO_4 may impede the vegetative growth of highly productive scions on less fertile soils** and should be avoided on these sites. This negative effect is intensified in extensively managed vineyards as well as those planted with cover crops.

4. Teleki 8B (V. berlandieri x V. riparia)

8B is currently the best rootstock for heavy to very heavy soils with moderate to vigorous growth characteristics. This variety has a positive effect on the scion, even at high soil lime contents. However, 8B is unpopular with grapevine breeders because it is difficult to graft. This is why the rootstock is only rarely used. Good results can be achieved with Riesling scions even on dry soils. This variety also reduces the risk of chlorosis especially on wet soils with high active lime contents.

5. Kober 125AA (V. berlandieri x V. riparia)

The growth characteristics of 125AA are similar to 5BB – without the negative effect on fruit set in sensitive sorts. This variety is especially lime and drought tolerant. The enduring dark green colour of the scion leaves is indicative of the excellent nutrient extraction ability of the 125AA. These advantages are the key to the increasing popularity of this variety among wine growers. Although 125AA is best suited for Pinot Noir scions, it will produce excellent results with any scion sort. On lime-rich, moist locations under extensive management, 125AA will ex-

ceed all other rootstock varieties apart from 8B.

6. Börner (V. riparia x V. cineria Arnold)

The Börner rootstock variety was first bred in Naumburg an der Saale. The potential of the variety was evaluated at the Institute for Grapevine Breeding and Grafting in Geisenheim. Börner was classified for the Federal Republic of Germany in 1991 and therefore this variety is relatively new to viticultural practice. The outstanding property of Börner is its complete resistance against Phylloxera. While all other classified varieties are more or less Phylloxera-tolerant, the insect cannot feed or breed on Börner. The growth characteristics of this rootstock are somewhere between the 125AA and 5C. Trials have indicated that the variety is capable of adapting to most soils found in Germany. Börner is a very drought-tolerant variety and is well-suited for dry, stony, light and shallow soils with moderate active lime contents. This rootstock does not grow well on heavy, clay dominated and waterlogged soils. Chlorosis is a danger on these locations. Börner will produce excellent results on light, well-drained soils even where the groundwater table is shallow.

7. Couderc 3309 (V. riparia x V. rupestris)

The French rootstock C 3309 induces moderate vigor in scions. High density plantations are only recommended on deep, fertile soils. C 3309 grows best on fresh, but not wet soils and has a very low drought tolerance. Therefore it is unsuitable for dry, shallow soils as well as wet and cool soils. C3309 also has a very low tolerance of active lime, which further restricts the range of suitable locations. The rootstock is especially suitable for coulure-suceptible scion cultivars on deep soils with high organic matter contents and a balanced water supply.

8. Binova

This variety is probably the female form of the SO_4. To a great extent, Binova and SO_4 have very similar properties, except in the case of lime tolerance. Binova is much more lime tolerant and is therefore suitable for lime-rich, loamy soils. This variety is a good rootstock for scion cultivars with sensitive flowers. Production values are very similar to those of SO_4.

9. Sori (Solonis x Riparia)

Just like Börner, Sori was first bred in Naumburg/Saale. This is a low-vigor variety, but unlike C 3309, Sori is very lime-tolerant. This rootstock is best suited for fertile, deep soils with a balanced water supply. Because this variety induces low vigour in the scion, it is not suitable for vineyards planted with cover crops or with widely spaced rows.

10. Riparia 1 Geisenheim

This variety induces low vigor in the scion and is very lime-sensitive. Since the introduction of wider row spacing Riparia 1 Geisenheim is no longer planted in vineyards of Hesse.

3.2 Scion cultivars

1. Riesling

Riesling grapes are the most important cultivar planted in the wine-growing regions of Hesse. About 83 % of the Rheingau vineyard area and 55 % of the Bergstrasse have been planted with Riesling. The Rheingau landscape is characterized by the Riesling grape which was formerly grown in field-blended vineyards. This late-ripening variety demands warm locations. The robust Riesling grows well on stony soils over rock substrates as well as on heavy soils. Because the wood matures early, this variety can also be grown in cooler regions. However, this practice is not recommended, since the wine produced under these conditions is inferior. Current cloning efforts are aimed at improving the Riesling and therefore increasing the quality of the wine.

2. Müller-Thurgau

The Müller-Thurgau vine was first created in Geisenheim at the end of the 19th century. About 5 % of the Rheingau vineyard area is planted with Müller-Thurgau. The main advantages of the variety are high productivity, early ripening and vigorous growth. Müller-Thurgau is not recommended for lower sites with reduced solar radiation - quality and production will suffer here especially if the vines are severely pruned. Moist locations will lead to early rot. On good soils in mid elevation sites, moderately pruned Müller-Thurgau vines will produce valuable wines. The Müller-Thurgau scion requires a vigorous rootstock.

3. Silvaner

This old variety is becoming less popular with wine growers in the Rheingau. Silvaner is less vigorous than the Riesling. The wood matures poorly so that the Silvaner is very sensitive to climatic conditions.

4. Pinot Noir

Pinot Noir is a very demanding quality wine variety, which can only thrive on good, warm locations. The variety is prone to mutations so that constant selection is required to maintain the original line. This has led to the development of several clones. Today, wine-growers may choose from a wide range of clones including the tried and tested standard types as well as those with loose cluster structure, small berries and upright growing shoots. Pinot Noir is very sensitive to environmental conditions and grows best on moderately vigorous rootstocks. About 10 % of the wine-growing area in Hesse has been planted with Pinot Noir.

5. Additional varieties

The following describes some additional varieties grown on less than 1 % of the vineyard area in Hesse.

The **Traminer** is a variety used for blending but also to produce pure wines. Traminer is a demanding vine and requires a good soil and favorable climatic conditions.

The **Ruländer** grows best on deep soils in good locations. This variety matures even in unfavorable years and then produces grapes with a high sugar content and balanced acidity. Early harvested Ruländer grapes yield a spritzy, fruity wine.

Pinot Blanc requires a deep, loamy soil with low top moderate lime contents. This vigorous variety is susceptible to chlorosis. Unfavorable climatic conditions have a strong effect on the Ruländer - the grape is recommended for good locations only. The wines produced from Pinot Blanc are better suited to our common viticultural methods than the Ruländer.

4. Soil type - rootstock recommendations

The following section discusses the compatibility of rootstock-scion grafts with the given site characteristics. The recommendations are based on the results of comprehensive trials and the practical experience of wine-growers in the field (Table 1). The soils were described in detail by ZAKOSEK (1967) who divided these into ecological groups. The soil map by E. THIEL has been revised and published along with a new description of the soil geography by FRIEDRICH & SABEL (2004). The climatic conditions have been described by KREUTZ & BAUER (1967), HORNEY (1975), HOPPMANN (1988) and HOPPMANN & LÖHNERTZ (1996).

Group I soils are usually limited to dry locations. Since irrigation is not normally possible, these soils cannot be utilized optimally for viticulture. In dry years Group I soils must be expected to cause damage due to water stress, especially due to premature cessation of growth. Less than 5 % of the soils of the wine-growing regions of Hesse are classified as Group I. Experience has shown that Kober 5BB and Börner rootstocks are the most drought resistant of the commonly used varieties. In dry years, these rootstocks will induce a more vigorous growth in Riesling scions and produce a greater yield per vine than any other rootstock. Both rootstocks are recommended for all scion varieties in Soil Group I locations. Since these soils are usually found at higher elevations, scion selection must take into account the adverse conditions of these sites. Riesling is not recommended for these locations, neither are Müller-Thurgau nor other large leaved varieties with a high water requirement. It is left to the grapevine breeders to create and test scion varieties suitable for higher elevations. Riesling is definitely the scion of choice for Group I soils in more favorable locations.

Group II soils comprise soils derived from a wide variety of parent rocks. These are moderate to deep, lime-free soils. From the plant physiological point of view, the soil water conditions of Group II locations are better than those of Group I locations. Since national viticultural regulations preclude irrigation, even in dry years, wine-growers must implement soil management practices specifically aimed at improving the water holding capacity and the conditions of the soil. Providing the climatic conditions are favorable, these sites are ideal for planting Riesling. Since the extent to which the soil conditions can be improved is limited, the selected rootstock varieties must be drought tolerant. Trials have shown that Berlandieri x Riparia rootstocks perform best on these locations. The recommended rootstock varieties for producing Riesling on Group II locations with favorable climatic conditions are 5C and SO_4. The vigorous varieties 5BB, 125AA and Börner are recommended for the drier and poorer Group II soils as well as for those sites planted with cover crops. These rootstocks are especially suited for the vigorous scion varieties Müller-Thurgau and Silvaner. All other scion varieties can be grafted to the same rootstock varieties recommended for Riesling.

Group III soils are optimal for viticulture and, under favourable climatic conditions, especially for growing Riesling. These deep soils are mostly found on plateaus and along the foot of the slopes. Since water supply is not a limiting factor in these lime-free soils, they provide ideal conditions for all rootstock varieties. This promotes vigorous growth of the rootstock, so that wine-growers are recommended to use moderately vigorous varieties such as 5C and SO_4. Under ideal conditions these varieties can be used for any scion variety. The rootstock variety 3309C from the V. riparia x V. rupestris group can also be grown in low density plantations on rich Group III soils with a granular structure. More vigorous varieties such as Börner or 125AA are recommended for vineyards with cover crops.

Group IV soils comprise the waterlogged and lime-free soils. Experience has shown that long periods of saturation during the vegetation period have a negative effect on grapevine growth. This is mainly caused by the coldness of these soils and the lack of biological activity when water-logged. In extreme cases the vineyards on these soils produce very unsatisfactory results regardless of the rootstock used. Growing wine on these sites is not recommended without implementing necessary soil management practices. Riesling scions perform well on 8B and SO_4 rootstocks in vineyards without cover crops, while Müller-Thurgau scions are best grafted to 125AA rootstocks. In vineyards with perennial cover crops Riesling and similar vigorous grape varieties should be grafted to 125AA and Börner as well as 5BB rootstocks.

Tab. 1. Soil groups of the wine-growing regions of Hesse and the recommended rootstocks for clean-cultivated and cover-cropped management systems

Soil-group	Soil	spatial distribution in %	without cover crops	with cover crops
I	predominantly shallow, very stony, dry, usually non-calcareous soils on slate, gravel, quartzite, magmatites or sandstones, occasionally containing loess	3,6	Börner 5BB 125AA	Börner 5BB
II	moderate to deep, stony, clay-containing, dry to moist, usually non-calcareous soils on slate, gravel, quartzite, magmatites or sandstones, frequently containing loess	125AA 18,4	Börner 8B, 5C SO_4	5BB 125AA Börner
III	deep, less coarse, clay-containin, moist, base enriched, granular, usually non-calcareous soils on clays and degraded loess	21,1	5C, SO_4, 125AA, Börner 3309C*	125AA Börner 8B, 5C
IV	clay-rich, occasionally stony, often waterlogged, usually non-calcareous soils on clays and degraded loess	7,1	SO_4, 125AA 8B,	125AA 8B
V and **Va**	deep, rarely stony, silty, rarely silty sandy, dry to moist, mostly calcareous soils on wind-transported sand and sandy loess (Va) or loess	35,3	125AA Börner 8B 5C, SO_4	5BB 125AA Börner
VI	deep, frequently stony, clay containing moist to wet, mostly calcareous soils on loess or fine alluvial deposits	2,6	8B, 125AA SO_4, 5C	125AA 8B Börner
VII	clay-rich, less stony, often waterlogged, mostly calcareous soils on marl	9,8	8B, 125AA	8B, 125AA 5BB

* only in low density plantations

Most of the vineyard soils in Hesse are found in soil Group V. These are the soils where Berlandieri x Riparia rootstocks achieve peak performance. The lime content of these soils precludes planting any other rootstock variety. These soils have a positive effect on quality and yield, even in wet years. The recommended rootstock varieties for Riesling and other grape varieties grown on these locations are 5C, Börner, SO_4 and 8B. The variety 5BB is recommended for drier areas. The rootstock varieties 5BB, 125AA and Börner are recommended for vigorous grape varieties. Rootstocks with vigorous growth characteristics are recommended for vineyards with cover crops.

The Berlandieri x Riparia rootstocks are also suitable for Group VI soils where the lime content also precludes the use of lime-sensitive varieties. Group VI soils promote vegetative growth and provide sufficient water for vine growth. The recommended rootstocks for these soils are lime-tolerant varieties such as 8B, SO_4, 125AA, and, with restrictions, 5BB and 5C. As a consequence of the vigorous growth of the vines on these soils, each plant requires more space than that provided in steep locations. Here it is recommended to graft vigorous grape varieties to Kober 5BB rootstocks.

Group VII soils are very difficult from the viticultural point of view: the large water holding capacity has a positive effect on vine growth in dry years, however, in wet years that same capacity can have a negative effect on the vine. Chlorosis is a common disorder. Measures to improve soil conditions are necessary in many locations. None of the available rootstock varieties is especially suitable for these soils. The best results can be achieved by using rootstocks from the Berlandieri x Riparia group, whereby variety 8B is least susceptible to chlorosis.

5. Conclusions

Any recommendations regarding the most suitable scion and rootstock varieties for a particular location require a holistic approach. The continuous developments in viticulture mean that recommendations are never final. New developments in rootstock breeding have caused winegrowers to revise viewpoints especially with regards to Vinifera-based varieties, which have proven to be susceptible to Phylloxera infestations. Experimental results will become much more important in future discussions concerning the selection of scion and rootstock varieties.

The Hessian Agency for Environment and Geology and the Institute for Grapevine Breeding and Grafting in Geisenheim have cooperated and set up a adaptation program for testing rootstock varieties on different locations. The results of this program have been incorporated in the recommendations given in this publication. The Institute for Grapevine Breeding and Grafting in Geisenheim together with other institutes involved in site conditions research are currently testing new scion and rootstock varieties. This is expected to have great implications for the future. The fundamental results of the present survey of the wine-growing regions are an important contribution to this project.

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