Investigations about the influence of some physiological and phenological characteristics on quality and their heredity

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Summary: The analysis of the offspring of 6 crossings with a total of 360 genotypes revealed that, of a total of 13 characteristics taken into account by the investigations, only the yield or the yield components, the beginning of berry ripening and the degree of botrytis infection have a significant influence on the sugar content of the must. About 60 % of the fluctuations in the sugar content of the must could be explained by these, whereby at approx. 35 % the beginning of berry ripening accounted for the highest percentage. The coefficient of determination for the three yield parameters which were investigated was between 12 and 19 %. The weight of the berries was the most important factor, while the number of clusters per shoot was nearly neutral with respect to its effect on the sugar content of the must. Consideration of these relations when selecting seedlings may, if only to a limited extent, lead to an increase in the success of selection for varieties with a high sugar content. It should be mentioned that these results, which were reached under the climatic conditions of Central Europe, cannot necessarily be applied to wine growing areas in other climates.

Some of the heritability levels determined differ considerably for the individual characteristics. While a low heritability coefficient was ascertained for the number of clusters per shoot, the single berry weight and the beginning of berry ripening indicate a high percentage of additive genetic effect, i. e. their degree in the offspring can be influenced to a great extent by the selection of the parents for crossing combinations.

By taking into account both the heritability levels when making the crossing combinations and the relations between these characteristics and the sugar content of the berries when selecting, a breeding programme to increase the sugar content is likely to make rapid progress. In addition, the selection criteria pointed out may be useful in clonal selection with regard to better quality. Last but not least, values for combining ability, which can be calculated by a similar model of variance analysis, may help by the identification of varieties.

Key words: genetics, heritability, crossing, selection, biometry, yield, must quality, maturation, botrytis.

Introduction

The quality of the must is not only affected by external factors such as climate or methods of cultivation, but also by the yield. As early as 1927 SARTORIUS identified this negative correlation between yield and the sugar content of the must, known as a quantity/quality ratio. Results of previous research (BÄDER 1979) showed that this quantity/quality ratio was not identical for every variety. It was also shown that the sugar content tends to correlate more negatively to the weight of the cluster than to the number of clusters per plant (ALLEWELDT and KOEPCHEN 1978). It is assumed that greater knowledge of the influence of the different yield parameters on the sugar content of the must and other substances such as acid and aroma compounds could mean an improvement of selection criteria within seedlings.

In continuation of previous research (ALLEWELDT and KOEPCHEN 1978) these investigations are primarily concerned with the influence of the yield parameters on the sugar content of the must.

Material and methods

Genotypes from 6 populations were studied in 1987 and 1988. For each population the sugar content of the must, the yield per plant as well as the yield parameters of approx. 60 individual plants were determined. Further characteristics which might have an effect on the sugar content were scored. These include the density of the clusters and the degree of botrytis infection at the time of the harvest, as well as phenological characteristics such as the beginning of flowering and berry ripening. The number of shoots per plant, which is hardly affected by genetic factors, is mainly determined by pruning. For this research it was standardized by retaining 10 buds per plant. A total of approx. 360 genotypes were included in the investigations.

In addition, the collected data was used to estimate the heritability coefficients for characteristics which influence the sugar content of the must. The design of the experiment corresponds to a diallel crossing model and enables one to estimate the variance components according to the variance analysis model with nested classification (WEBER 1978; WRICKE and WEBER 1986).

Results and discussion

By using multiple regression analysis the influence of all recorded parameters on the sugar content of the must can be determined. First of all, only the total yield per plant is taken into account instead of the individual yield parameters. The summarized results in Fig. 1 show that the only characteristics which have a significant effect on the sugar content of the genotypes used in the research are the yield per plant, the beginning of berry ripening and the degree of botrytis infection.

Variations of these characteristics explain 51 % of the fluctuations in the sugar content of the berries. It is at first surprising that the total yield accounts for only 8 % of the differences in the sugar content of the must, while the percentage for the beginning of berry ripening is about 4 times as high at 34 %. If the yield is replaced by the individual yield parameters for the statistical analysis, the results are as follows (Fig. 2): The single berry weight accounts for 8 % of the variations of the sugar

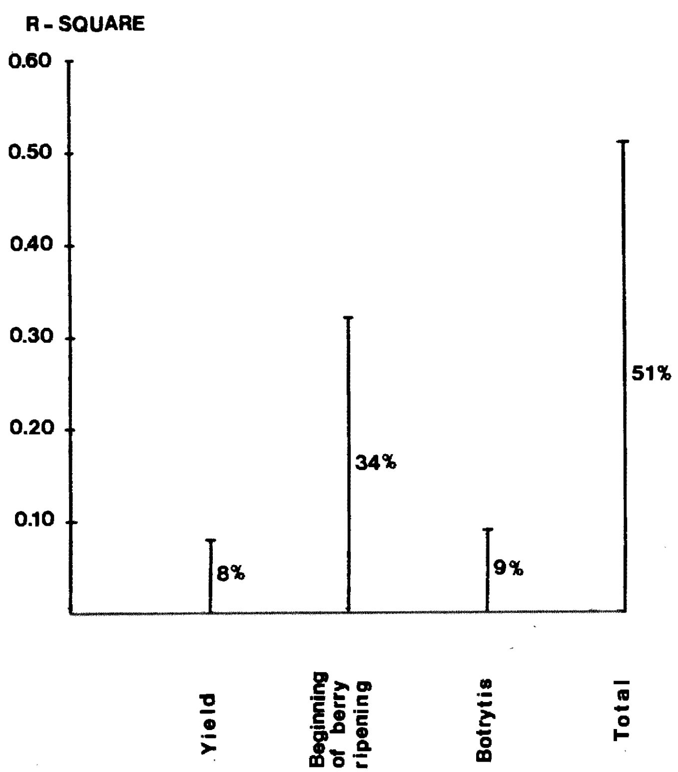

Fig. 1: Yield and other characteristics affecting the sugar content in berries (n = 357); probability of F > 0.05.

content of the berries, thus reaching the same level as the total yield in Fig. 1. The sum of the single coefficients of determination for all yield parameters now reaches 14 %. These results show that a considerably higher percentage of the fluctuations in the sugar content can be explained by the individual yield components than by the total yield per plant. It also becomes evident that the individual yield parameters affect the sugar content of the must to varying degrees. Because of the existing but more or less weak positive correlations between yield per plant and yield parameters, and negative correlations between the different yield parameters, this analysis can imply only tendencies. These weak correlations can be explained by the yield structures of the seedlings, some of which vary considerably.

As an example of this, Fig. 3 shows the number of berries per cluster compared to the total yield. The mass of points indicates the relation between the two characteristics. However, it covers a large area and there are many stray points. Genotypes which lie within a very limited area and thus have a high correlation between the number of berries per cluster and the total yield were now chosen for further calculations. For these genotypes the variation of the yield per plant depends mainly, but not exclusively, on the variation of the number of the berries per cluster. For such selected genotypes as these a correlation coefficient of $r > 0.98$ between the number of berries and the yield as well as a minimum of 55 genotypes was fixed. By shifting this marked area parallel to

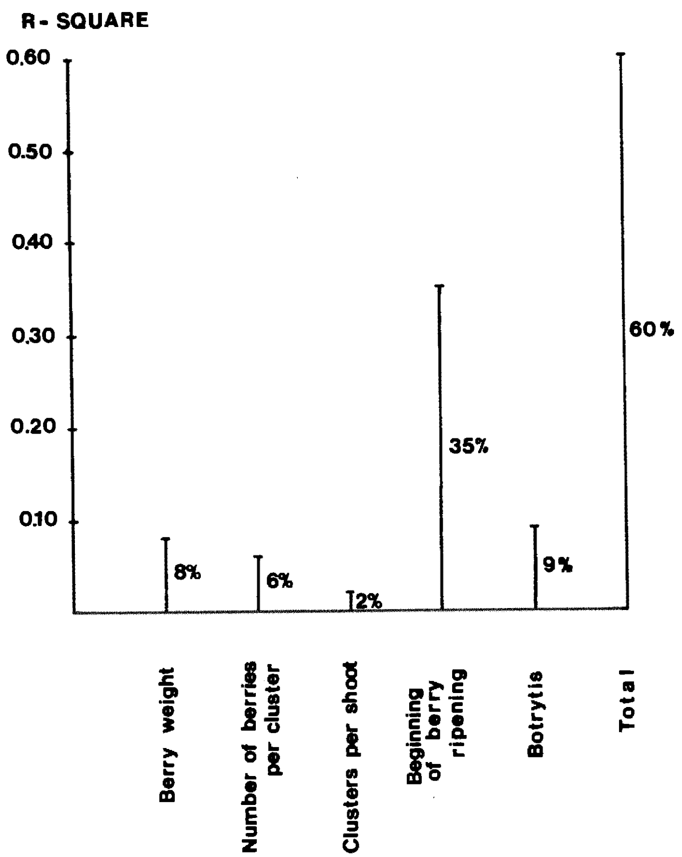

Fig. 2: Yield parameters and other characteristics affecting the sugar content in berries (n = 357); probability of $F > 0.05$.

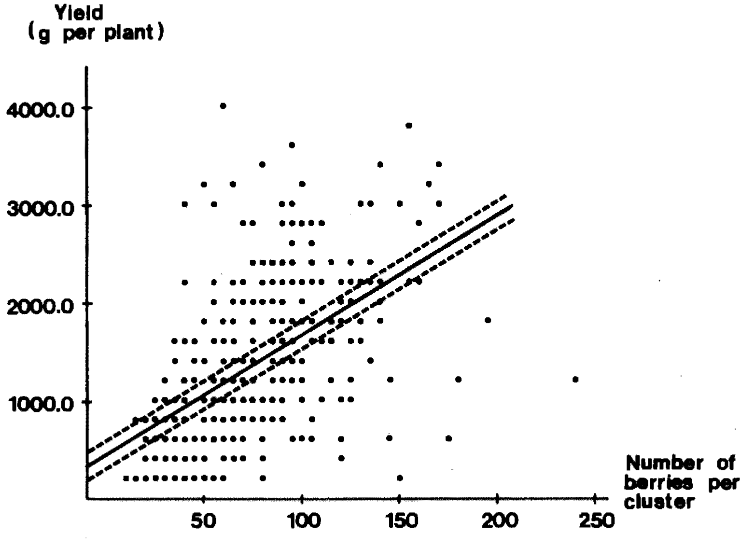

Fig. 3: Number of berries per cluster plotted against total yield per plant with corresponding regression line (n = 357).

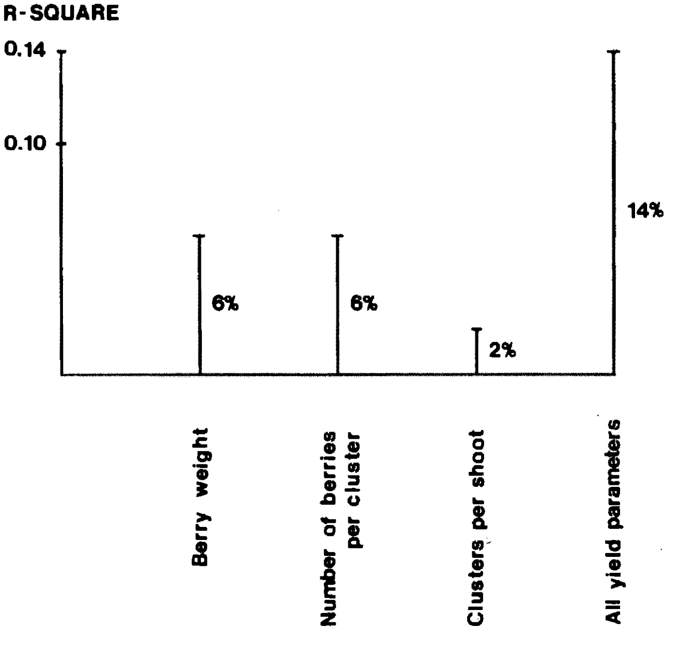

Fig. 4: Influence of yield parameters on sugar content of berries; selected genotypes with r › 0.98 between total yield and number of berries per cluster (n > 55).

the regression line, groups of genotypes can be found which show various yield levels, but still meet the requirements mentioned. It was possible to form between 4 and 6 groups for each yield parameter. The multiple correlation coefficients were calculated for each group.

Fig. 4 shows the means from these evaluations for the number of berries per cluster. When an increase in yield is mainly the result of the number of berries per cluster thus maximizing the variation of the number of berries and minimizing the variation of the other yield parameters, the fluctuations in the sugar content of the must can be explained as follows: 6 % by the number of berries per cluster, 6 % by the single berry weight and 2 % by the number of clusters per shoot. If the same principle is used for the single berry weight, which is maximizing the variation for this yield parameter, the results shown in Fig. 5 are reached: Now the single berry weight is responsible for 12 % of the fluctuations in the sugar content of the must. At 6 % the coefficient of determination for the number of berries is 50 % lower and the number of clusters per shoot only reaches 1 %.

Fig. 6 shows the summarized results when the variation of the number of clusters per shoot is maximized. Despite the increase in yield due primarily to the number of clusters per shoot, only 3 % of the fluctuations in the sugar content of the must are subject to this parameter, whereas the figure doubles for fluctuations due to the single bery weight.

In addition to the practical consequences for the selection of seedlings which can be derived from these relations, the type of heredity of these characteristics is of special interest to the breeder. With knowledge of the coefficients of heritability, he might be able to influence the degree of the characteristics within the offspring by selecting suitable parents. In so doing, he might be able to increase the success of selection.

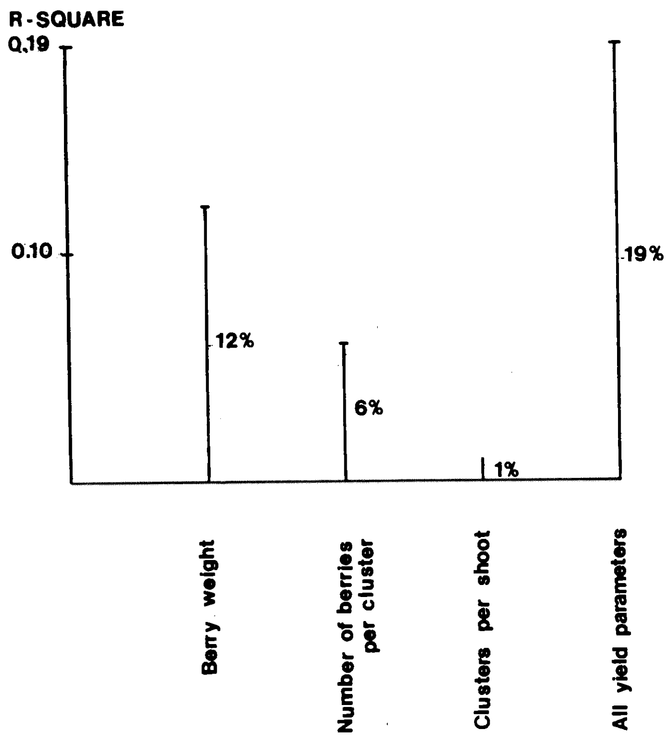

Fig. 5: Influence of yield parameters of sugar content of berries; selected genotypes with r > 0.98 between total yield and berry weight (n > 55).

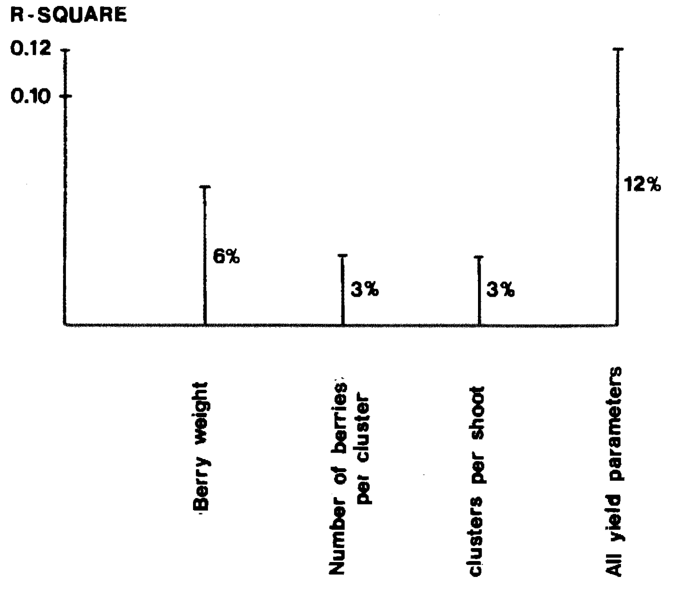

Fig. 6: Influence of yield parameters on sugar content of berries; selected genotypes with r > 0.98 between total yield and clusters per shoot (n > 55).

The most important parameter for cross-breeding with regard to polygenic characteristics (such characteristics are being dealt with exclusively here) is the heritability in the narrow sense. In this case only additive genetic effects are taken into account while dominant gene effects, which reduce the breeding value of a variety, are omitted.

For the investigations the same 6 populations were used. The populations were progenies of two female parents, Sirius and Gf. Ga-54-14, both fungus resistant varieties of BFAR - each crossed with the male parents Maréchal Joffre, Vidal blanc and Bellandais noir.

Fig. 7 shows the frequency of the single berry weight in each population. The range of variation extends from 0.5 g to 3.1 g per berry. The low single berry weight of Maréchal Joffre is evident in the offspring of this variety, where the frequency distribution deviates to the left in each case. None of the genotypes produced from a crossing with this variety had a single bery weight of more than 2.0 g. When the male parents Bellandais noir and Vidal blanc are compared, there are traces of a frequency distribution of the crossing with Bellandais noir which deviates somewhat towards a higher single berry weight. This corresponds to the somewhat higher single berry weight of this variety compared to Vidal blanc. There are no significant differences between the female parents, which is evidenced by their nearly equivalent single berry weight. The horizontal bar drawn across the frequency distribution shows the range of variation of the parent varieties. On the one hand, the single berry weights of the offspring are also concentrated within this area but, on the other hand, the deviations to the left and to the right are nearly equal, thus indicating a relatively high percentage of additive genetic effects. One would expect a clearer deviation of the frequency distribution either to the left or to the right if the degree of the characteristics in the parent varieties was mainly subject to dominant genes.

Contrarily to the single berry weight, a differentiation of frequency distributions for the number of clusters per shoot both between the male parents within a female parent and between the female parents is nearly impossible (Fig. 8). The curve is very similar for all the crossings.

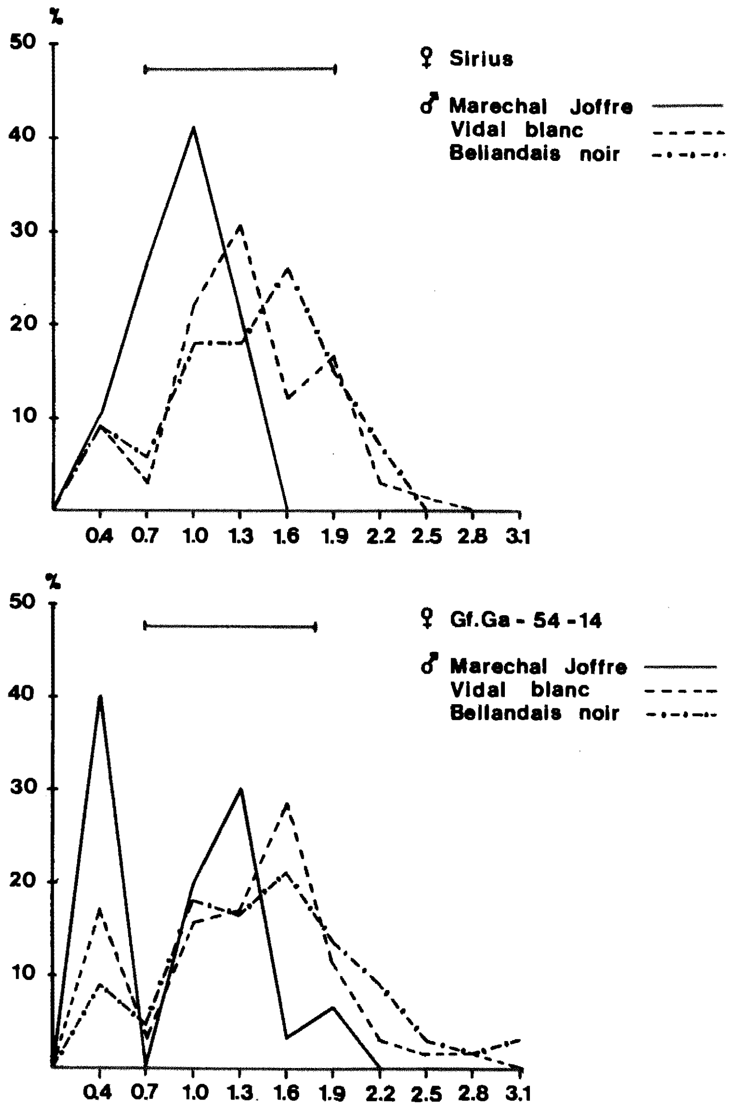

Fig. 7: Distribution of frequency of mean berry weight for some selected cross populations.

Particularly in the crossings with Gf. Ga-54-14 the frequency distributions of the offspring deviate clearly from the range of variation of the parent varieties. The Gf. Ga-54-14 variety, which is characterized by a high average number of clusters per shoot, does not seem to transmit this characteristic well.

The calculated heritability coefficients for both the yield per plant and the individual yield components are shown in Table 1. The mean for the heritability coefficients over the 2 years of research for the yield per plant is 50 %. At 69 % the single berry weight has the highest heritability coefficient of the yield parameters and at 12 % the number of clusters per shoot has the lowest.

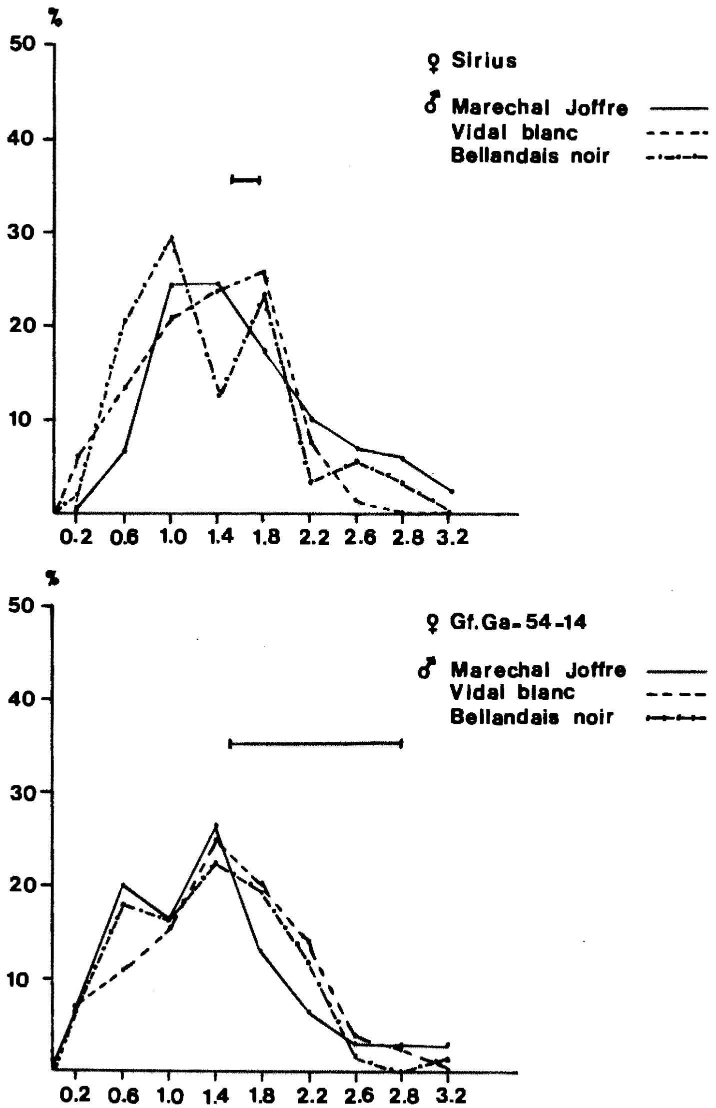

Fig. 8: Distribution of frequency of clusters per shoot for some selected cross populations.

According to this, the markedness of the characteristic of single berry weight in the offspring is the most easily influenced characteristic when selecting the parents for the crossing combination. In contrast, the high number of clusters per shoot is apparently due to a great degree to dominant genetic effects. Therefore, for varieties with a high number of clusters per shoot, a low breeding value for this characteristic can be expected.

As mentioned at the outset, the sugar content of the berries is not only influenced by the yield parameters, but also by the extent of the botrytis infection and, above all, by the beginning of berry ripening. There is no point in calculating the heritability of the resistance to botrytis infection since it

Table 1: Calculated coefficients of heritability for yield and components of yield

	heritability (%)		
Characteristic	*1987*	*1988*	*Mean*
yield	46	54	50
mean berry weight	73	65	69
number of berries	31	38	35
clusters per shoot	10	13	12

Table 2: Calculated coefficients of heritability for begin of berry ripening and density of cluster

	heritability (%)		
Characteristic	*1987*	*1988*	*Mean*
beginning of berry ripening	58	44	51
density of cluster	25	28	27

strongly correlates to the stage of ripening, and it is not possible to standardize. However, the evaluations show that the density of the clusters, in particular, strongly influences the degree of botrytis infection, which is reflected in the highly significant correlation of $r = 0.42$. In addition to the yield parameters, Table 2 shows the heritability levels for the beginning of berry ripening and for the density of the clusters. A medium heritability coefficient of 51 % was reached for the beginning of berry ripening. According to this, this characteristic is inherited quite well. The low dependency of the density of the clusters on the environment and the relatively low heritability in the narrow sense at 27 % imply a high percentage of dominant genetic effect and, therefore, a type of heredity which is not very much influenced by the selection of the crossing parents.

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Potassium uptake of rootstock varieties and hybrids - implications for wine quality

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Abstract: Australian wines, in particular those from hot irrigated areas, often have high pH values, which leads to low acidity, brownish colour and microbial instability. High K concentrations have been implicated in the development of high pH in grape juice and wine from these regions. Studies in the hot irrigated areas have demonstrated effects attributable to rootstocks on K concentrations and the pH of grape juice.

In field studies a correlation was found between the rootstock effects on scion grape juice pH and K accumulation in the petioles of ungrafted rootstock plants. This indicates that the effect of rootstocks on the scion grape juice pH is linked to their ability to accumulate K. The rootstock varieties Dog Ridge, Rupestris du Lot and Freedom had high K accumulation in their petioles and gave high scion grape juice pH, while the varieties 140 R, 1103 P, 1202 C had low K accumulation in their petioles and low scion grape juice pH.

The results indicate that measurement of K accumulation in the petioles of ungrafted rootstocks has potential for routine screening of genotypes which will result in low grape juice pH with grafted scion varieties and improved wine quality.