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The heritability of fruit ripening date in Vitis vinifera L.

by

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Die Erblichkeit des Reifungszeitpunktes der Trauben von Vitis vinifera L.

Zusammenfassung. — An 2200 Genotypen von *Vitis vinifera* aus 55 Familien, die aus der Kreuzung von 35 Elternpflanzen hervorgegangen waren, wurde die Vererbung des Reifungstermins der Trauben analysiert. Es zeigte sich, daß dieses Merkmal durch Gene bestimmt wird, die in hohem Maße additiv wirken. Der Heritabilitätskoeffizient des Merkmals wurde auf $0{,}50 \pm 0{,}04$ geschätzt. Der durchschnittlich zu erwartende Leistungszuwachs bei der Nachkommenschaft zufällig gepaarter Eltern, die zu den oberen 10 Prozent ihrer Generation zählten, wurde errechnet. Die Befunde weisen darauf hin, daß bei einer solchen Population ein relativ rascher Kreuzungserfolg erwartet werden kann, wenn man die Eltern aufgrund ihrer Leistungseigenschaften auswählt und sie anschließend untereinander kreuzt.

Introduction

The early ripening varieties of fruits often command a price premium in the market place. This is particularly true of table grapes which can be grown in the hot desert areas with warm winter climates where most deciduous fruits are unsuccessful. An important phase of the grape improvement program at the University of California, Davis, seeks to advance the season of maturity in table grapes.

Estimates of "heritability" obtained in a wide variety of agronomic species (see for example 12), and more recently in a few perennial clonal horticultural species such as sweet cherry (5), peach (7), walnut (8), and strawberry (6) have been found to be useful guides in varietal improvement programs for (a) determining the veracity of employing a breeding method in which parents are selected on the basis of their own performance and (b) to establish the likely per generation rate of gain that could be expected from such a breeding method.

The purpose of this study was to obtain an objective quantitative estimate of the rate that offspring fruit ripening date can be changed in the *Vitis vinifera* breeding stock at University of California, Davis by selecting (and mating *inter se)* parents with extremely early (or late) ripening dates. The possible injurious effects of some degree of inbreeding are not considered, but it is known that inbreeding leads to reduced growth and fruitfulness of these highly heterozygous cultivars.

Materials and Methods

The population under consideration consisted of 2200 offspring of 55 families generated by crosses among 35 parents. Progenies from controlled crosses were planted on their own roots at the San Joaquin Valley Research and Extension Center, Parlier, California. Sibs within progenies were planted adjacently in progeny rows.

[1]) This study is a portion of a thesis submitted by the senior author as partial fulfillment of the Master of Science degree in Horticulture, Univ. of Calif., Dept. of Viticulture and Enology, Davis, Calif. U.S.A.

The populations used in this study were a part of the grape breeding program of the University of California at Davis. The crosses were made in 1966. Seedling progenies were grown in the greenhouse in steam sterilized sand-peat mixture, then transplanted directly to the vineyard in June 1967, at spacing of 2 ft. in the row, and rows 12 ft. apart. The stand of vines was practically complete. The vineyard soil was fumigated prior to planting and no adverse affects of soil pests such as nematode or phylloxera were encountered. The vines were trained upright on a vertical trellis to a height of 5 feet, and pruned to three spurs of 2 nodes each spaced along the upper third of the vine. This prevented overcropping, which is known to delay maturity of the fruit. Seasonal effects are known to influence date of ripening, but the sequence between cultivars is maintained. Most of the vines first fruited in 1969. The parental vines were grown in a neighboring block under similar cultural conditions.

Every two days during the ripening season of 1971, the degree of maturity of grapes was checked on all the 5 year-old seedlings, which were in bearing for the second season. Juice from several berries, collected at random among clusters of each vine, was used to obtain the percentage of soluble solids with a Zeiss hand refractometer. The ripening date was recorded when the soluble solids reached the value of 16° Balling. This value is fixed as the minimum percentage of soluble solids by United States Standards for some table grape varieties (13), and was suggested also by Cosmo *et al.* (2) as a satisfactory index for the commercial acceptance of table grapes.

The actual dates of ripening, collected during the season 1971 (Fig. 1) on both parental and offspring vines for statistical analysis, were transformed to the number of days from June 1.

Heritability was estimated from the linear regression of individual offspring performance records on the average performance of their parents, the mid-parent performance being repeated within progenies (1).

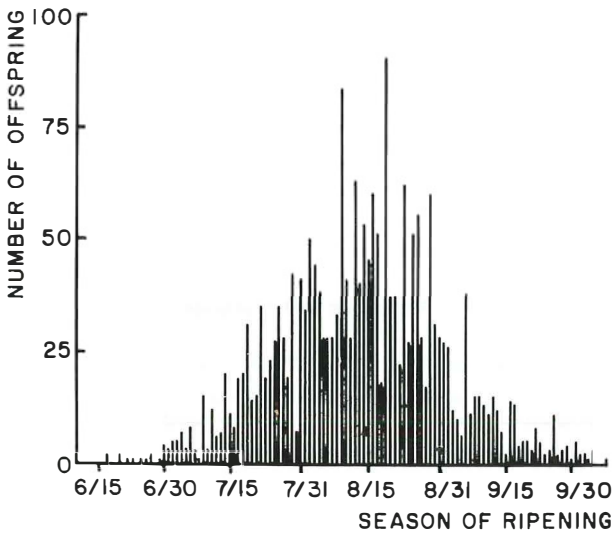

Fig. 1: Histogram showing distribution of ripening date among offspring.
Histogramm der Verteilung des Reifungszeitpunktes in der Nachkommenschaft.

Results and Discussion

The average ripening date of parents utilized in this study was 68 days from June 1 and that of their offspring was 77 days from June 1. The difference in the distribution of ripening dates among parents and offspring ($\hat{\delta}_p = 10.3$ vs. $\hat{\delta}_o = 19.4$ days) is merely evidence of the fact that the parents were selected to some extent for early ripening.

The relationship between parental and offspring performance is illustrated in Fig. 2, where the mean ripening date of each family is plotted against the mid-parent mean. Heritability of fruit ripening date was estimated to be 0.497 ± 0.04. Since the precision of this estimate is reasonably high, the heritability estimate should provide a reliable predictor of genetic gain when parents are selected on the basis of their phenotypic value. The expected average genetic gain per generation, E_g, can be predicted from the equation $E_g = i.\hat{o}.\hat{h}^2$, where $\hat{o}$ is the standard deviation of the parental population, $\hat{h}^2$ is the heritability and i (the intensity of selection) is the difference between the overall mean of selected parents and the mean of the population from which the parents were selected, expressed in standard deviation from the population mean (3). If we assume the proportion of selected parents is

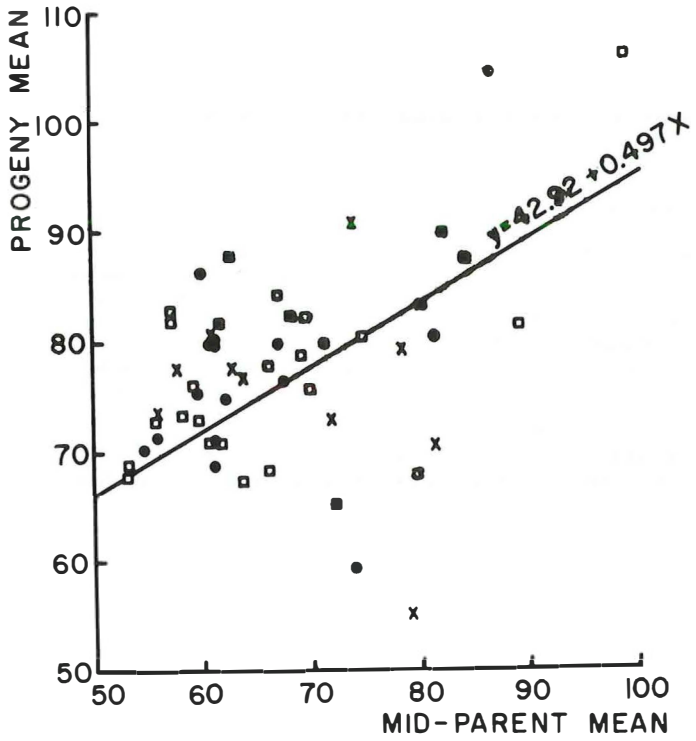

Fig. 2: Heritability of ripening date; each progeny mean plotted against mid-parent mean (days from June 1); x = 5 to 10 offspring per progeny; • = 10 to 30 offspring per progeny; □ = more than 30 offspring per progeny.
Erblichkeit des Reifungszeitpunktes: Mittelwerte der Nachkommenschaft in Beziehung zu den Mittelwerten der Elterndurchschnitte (Anzahl Tage nach dem 1. Juni); x = 5—10 Sämlinge je Nachkommenschaft; • = 10—30 Sämlinge je Nachkommenschaft; □ = mehr als 30 Sämlinge je Nachkommenschaft.

10%, then i is equal to 1.75 standard deviations and $E_g \sim 17$ days. This result indicates that selecting superior seedlings as parents on the basis of their ripe date in the second year of crop should be very effective in improving the mean of this trait of this foundation stock. A gain of approximately 25% of the mean of the parental population each generation should be possible.

Summary

An analysis of the inheritance of fruit ripening date in *V. vinifera* grapes, based on data collected on 2200 genotypes from 55 families generated by crosses among 35 parents, reveals that this trait is controlled by genes highly additive in their effects. The heritability of this trait was estimated to be 0.50 ± 0.04. The expected average gain of the progeny of randomly mated parents ranked in the upper 10 percent of the parental generation was calculated. The results indicate that relatively rapid genetic gain can be expected in this population by selecting parents on the basis of their own performance and subsequent mating *inter se*.

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