

Inheritance of seedlessness in seeded × seedless progeny of *Vitis vinifera* L.

by

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Die Vererbung der Kernlosigkeit auf die Nachkommen der Kreuzungskombination „kernhaltig × kernlos“ bei *Vitis vinifera* L.

Zusammenfassung: In 5jährigen Versuchen wurden kernhaltige (Mutter) und kernlose (Vater) *Vitis vinifera*-Reben gekreuzt und die Verteilung des Merkmals „Kernlosigkeit“ bei den Nachkommen analysiert. Die Aufspaltung in kernhaltige und kernlose Sämlinge erfolgte nahezu im Verhältnis 3 : 1. Der χ^2 -Wert für die einzelnen Jahre (1983, 1984, 1985, 1986, 1988) betrug 0,03; 0,11; 1,17; 1,97 und 3,01. Die Homogenität für χ^2 lag nur 1986 innerhalb der tolerierbaren Grenzen (0,3—0,5). Die meisten Populationen hatten in allen Jahren χ^2 -Werte, die dem 3 : 1-Verhältnis entsprachen. Zwei Independenz-Tests für aufeinanderfolgende Jahre ergaben keine Interaktionen. Auf der Grundlage dieser Ergebnisse wird postuliert, daß die Vererbung der Kernlosigkeit durch zwei komplementäre rezessive Gene bestimmt wird. Nur bei 30,7 % der als „kernlos“ klassifizierten Kreuzungsnachkommen konnten die Kernreste organoleptisch nicht wahrgenommen werden.

Key words: table grape, berry, seedlessness, stenospermocarp, seed trace, crossing, genetics, segregation ratio, recessive gene.

Introduction

In numerous countries a definite consumer preference for seedless grapes is being evidenced. Because of the larger potential berry size, that can be further enhanced by gibberellin applications (WEAVER 1958), stenospermocarpic types are favored as table grapes to those showing stimulative parthenocarp.

In stenospermocarpic cultivars, pollination and fertilization are followed by various degrees of embryo abortion (PEARSON 1932). Such cultivars have viable pollen and are used as male parents with normal seeded genotypes in order to produce some progeny with aborted seed. Analyzing the proportion of seeded to seedless progeny in such crosses, contradictory conclusions have been drawn (STOUT 1936, 1939; WEINBERGER and HARMON 1964; OLMO and BARIS 1973). It has been also stated that back crosses to seedless genotypes were not always effective. Crosses between seeded cultivars or selections gave only 5 seedless hybrids out of a population of 1762 individuals (WEINBERGER and HARMON 1964). Hence the conclusion that seedlessness appears to be a recessive character. We have carried out analyses of progenies from crosses between seeded and seedless parents during 1983, 1984, 1985, 1986 and 1988.

Results and conclusions drawn are communicated in the present paper.

Materials and methods

Fruiting progeny from crosses between seeded parents and seedless parents used as male donors were analyzed and classified organoleptically by a panel of 3 judges into seeded (N) and seedless (SS). Due to variation in seed vestiges in seedless grapes,

the latter were divided into two groups: Small vestiges barely discernible in the pulp (S), and aborted seed with appreciable portions of sclerenchyma in the integuments, with the texture of the seed differing markedly from the texture of the pulp (B). Various seedless male parents were used; the largest number of crosses were made using the following: Sultanina, Perlette, Flame Seedless and L12 (a large-berried type). The number of different seeded parents used was 13 in 1983, 17 in 1984, 13 in 1985, 13 in 1986 and 19 in 1988.

The number of populations analyzed each year can be deduced from Table 1 (degrees of freedom for determination of homogeneity chi-square plus one). Statistical analysis included testing of hypothesis by the chi-square method, test for independence and calculation of homogeneity chi-square.

Results

The number of hybrids, seeded (N) and seedless (B + S) is given in Table 1. Assuming a theoretical distribution of 3 seeded : 1 seedless, χ^2 values (after using Yates correction) are given for each year. In all cases χ^2 values are small enough (probabilities > 0.05) and point to acceptance of hypothesis.

During 4 years out of 5, homogeneity χ^2 has been outside the accepted limit, signifying that the samples have not been homogeneous. Only in 1986 with a χ^2 of 27.77 and d.f. of 26, probability of the χ^2 value was between 0.30 and 0.50. As each progeny has been analyzed separately for χ^2 , number of population with a χ^2 that fits the assumption of a 3 : 1 ratio is also given. In all cases number of populations in which χ^2 values have a probability > 0.05 clearly exceeds the number of populations in which the hypothesis of the 3 : 1 segregation had to be rejected.

Table 1

Segregation of *Vitis vinifera* progeny for seedlessness from crosses between seeded (female) and stenospERMOCARPIC (male) parents · Postulated segregation ratio 3 seeded : 1 seedless

Die Aufspaltung des Merkmals „Kernlosigkeit“ bei den Kreuzungsnachkommen aus kernhaltigen (weiblichen) und stenospERMOKARPEN (männlichen) *Vitis-vinifera*-Sorten · Gefordertes Aufspaltungsverhältnis „kernhaltig : kernlos“ = 3 : 1

Year	No. individuals	Normal seeded (N)	Seedless		χ^2	Homogeneity		No. populations	
			Noticeable seed traces (B)	Slight seed traces (S)		χ^2	d.f.	$\chi^2 > 0.05$ accepted	$\chi^2 < 0.05$ rejected
1983	483	364	85	34	0.03	68.86	23	20	4
1984	705	580	125	63	0.11	59.34	23	18	6
1985	661	545	116	49	1.08	76.20	24	17	8
1986	1240	1003	237	128	1.97	27.77	26	26	1
1988	1988	1457	391	140	3.01	80.50	22	16	7

We have also performed tests for independence (contingency χ^2) comparing data of 1984 and 1985, and in another set those of 1986 and 1988 (Table 2). In both cases the calculated χ^2 is significantly lower than the χ^2 value at the 5 % level. Thus no interaction effect to cause differences in results is evident. While hybrid seedlings bearing

fruit with seed traces have been pooled together with those yielding no noticeable seed traces in testing genetic ratios of seeded vs seedless, their separate determination as

Table 2

Contingency chi-square for data on segregation of progeny from seeded \times seedless crosses of *Vitis vinifera* for seedless

Kontingenz des χ^2 -Tests für die Aufspaltung des Merkmals „Kernlosigkeit“ von Kreuzungskombinationen „kernhaltig \times kernlos“ (*Vitis vinifera*)

Year	Seeded progeny	Seedless progeny	Contingency χ^2
1984	580	188	1.24
1985	545	165	
1986	1003	365	0.04
1988	1457	531	

performed is still of obvious practical significance. 'S' types (seedless) are clearly preferred to 'B' (seedless types with noticeable seed traces). Table 3 summarizes the proportion of the two groups, indicating a preponderance of the group with seed traces. Thus, while the ratio of hybrids bearing seedless fruit from progenies of a seeded \times seedless approximates 1 : 3 (Table 1), only about 30 % of the seedless progeny bore, under conditions prevailing in our breeding block, fruit without noticeable seed traces. This amounts to about 7.5 % only of the total progeny obtained (Table 3).

Table 3

Proportion of progeny with seed traces barely noticeable (S) in total progeny rated as seedless (B + S) from crosses between seeded \times seedless (*Vitis vinifera*)

Anteil der Nachkommen mit kaum wahrnehmbaren Kernresten (S) an der gesamten als „kernlos“ (B + S) klassifizierten Nachkommenschaft aus Kreuzungen „kernhaltig \times kernlos“ (*Vitis vinifera*)

Year	Number of seedless progeny	Progeny with barely noticeable seed traces	
		Number	Percentage
1983	119	34	28.6
1984	188	63	33.5
1985	165	49	29.7
1986	365	128	35.1
1988	531	140	26.4

A segregation of 3 : 1 between seeded and seedless in the total number of individuals produced from seeded \times seedless crosses of *Vitis vinifera*, each year, points to the 'seedless trait' as depending on two complementary recessive genes (aass). Probably most, if not all seeded cultivars can thus be regarded as heterozygous dominants for the seeded condition (AaSs). This would yield in F₁ from crosses between seeded and seedless a 3 : 1 ratio.

Discussion

Crosses between seeded *V. vinifera* as a female parent and seedless types as a male parent have been known to yield a varying number of seedless progeny. Our work clearly shows that seedlessness is a recessive trait. Moreover, counts made during 5 nearly consecutive years (similar work in 1987 was not completed) show that a 3 : 1 ratio is being obtained, if results of all progenies derived from such a cross are pooled. Number of hybrids analyzed ranged from 483 to 1988. On the basis of the results obtained, inheritance of seedlessness seems to be determined by two complementary recessive genes. Nearly all seeded cultivars used as a parent yielded also seedless progeny and can thus be considered heterozygotes. However, some of the populations from certain crosses deviated sharply from the 3 : 1 ratio, causing high χ^2 values in 4 out of the 5 years examined.

Examination of the performance of seedless parent used in the crosses (results not given) does not seem to reveal significant differences as to proportion of seedless progeny obtained, though differences in the proportion of seedless progeny with very slight seed traces to those with noticeable seed traces seem indicated. In contrast, crosses involving certain seeded parents do show differences in the proportion of seeded to seedless in the progeny. For an exact comparison to be valid, a diallele setup and analysis are required. If inheritance does depend on two complementary recessive genes, backcrosses to about 2/3 of the seeded parent derived from a seeded \times seedless cross could show a more favorable segregation, increasing chances of seedlessness up to 50 %. Crosses of AaSs (seeded) and aass (seedless) would yield AaSs, aaSs, Aass and aass. Crosses of Aass or aaSs (though their phenotype will be indistinguishable from AaSa) would yield a 1 : 1 segregation instead of the 3 : 1 ratio of seeded : seedless when AaSa is used as a female parent. Similar crosses made in the past could have given a 1 : 1 ratio, originating the assumption that seedlessness behaves as a dominant trait (STOUT 1939; OLMO and BARIS 1973).

All our crosses have been performed with stenospermocarpic male parents. Seed traces of varying size are obtained in the seedless progeny, ranging from nearly unnoticeable traces smaller even or comparable to those obtained in Sultanina to large seed traces unaffected by gibberellin treatments during bloom. Hybrids with stenospermocarpic fruit have been divided by us into two subclasses, based on extent and nature of seed traces in the fruit. The percentage of hybrids bearing fruit with small vestiges barely discernible in the pulp has been found to vary different years between 26.4 % and 35.1 % of the totality of the hybrids considered seedless. This would amount to only 6.5—8.3 % of the total progeny from seeded \times seedless crosses. With the aid of the new *in vitro* method of culturing ovules and embryos of seedless parents (EMERSHAD and RAMMING 1984; SPIEGEL-ROY *et al.* 1985), a very high proportion of seedless progeny is being obtained from hybrids of crosses performed between two seedless parents. Genetic ratios from such crosses will be reported in another paper.

Summary

Progenies derived from seeded (female parent) and seedless (male parent) *Vitis vinifera* have been analyzed during 5 years for number of hybrids bearing seeded vs seedless fruit. Distribution closely approximated a 3 : 1 ratio. χ^2 for the different years (1983, 1984, 1985, 1986, 1988) were 0.03, 0.11, 1.17, 1.97 and 3.01. Homogeneity of χ^2 was

within the accepted limit (0.3—0.5) only in 1986. Most of the populations during all years had χ^2 conforming to the 3 : 1 ratio. Two tests for independence during consecutive years showed no interaction. On the basis of these results, inheritance of seedlessness is postulated to depend on two complementary recessive genes. Only 30.7 % of the progeny rated as seedless bore fruit without noticeable seed traces.

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