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Reproducible Differences in Yield between Sultana Vines

by

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Introduction

Since the early work of Sartorius (1926, 1928) clonal selection has been widely adopted for the improvement of wine grapes in Europe. Positive results both for yield and for other fruit characters have been reported by, among others, Peyer (1950) for Pinot noir, Leyvraz (1958) for Chasselas doré, Huglin and Julliard (1962) for several varieties, and also recently by Olmo (1964) for a few varieties in California.

On the other hand Bioletti (1926) concluded from a large experiment with Muscat of Alexandria that no improvement could be expected from selection based on yield only without any other distinguishing character, a view which has been reiterated by Winkler p. 152 (1962). Soldatov (1956) also considered that transmissible differences in yield could be expected only from vines differing also in morphological characters.

Levadoux (1951) has suggested that in fact Bioletti was working with a single uniform clone, on the grounds that introductions of grape varieties into the U. S. A. have been on a small scale and relatively recent in time. Such considerations would also apply to the introduction of sultanas into Australia. However large and consistent differences in yield have been recorded between adjacent sultana vines in the Mildura district (e. g. Antcliff 1965).

The present experiment was undertaken to test whether such differences in yield between sultana vines, which are grown in Australia on their own roots, were reproducible by vegetative propagation.

Method

The best available data on which to base selection were from the work of Antcliff, Webster and May (1956, 1958) and Webster (unpublished). Yields of fresh fruit for at least four consecutive years from about 50 vines on each of four sites were available from these trials. One site was on a heavy soil (A), one on a light soil (B), and two on medium soils (C and D). On site A the vines were five years old and on the other sites at least 16 years old when recording began. On sites A, B and D all vines were pruned to six 14-bud canes each year; on site C the 25 vines in each of the 6- and 7-cane treatments in a pruning trial were used, all canes being of 14 buds.

On each site four pairs of adjacent vines which showed consistent big differences in yield without obvious differences in vegetative vigour within each pair were selected. Pairs of adjacent vines were used to reduce environmental variation to a minimum and vines with the highest and/or lowest yields on each site were thus not necessarily included.

From each selected vine ("source vine") ten single-bud cuttings from each of the fifth and ninth bud positions on one-year-old shoots were taken in June 1957

These were treated with ethylene chlorhydrin to break dormancy and after bud-burst those which rooted were grown in a glasshouse. When the new shoots were 35 inches long they were tipped and after "hardening off" the vines ("propagules") were transplanted to their field positions. Propagules from the ninth bud position on each pair of source vines were planted adjacently in the vine rows in 72 groups of two vines and 29 groups of four vines randomised over 12 rows of 24 vines; the four-vine groups also included corresponding pairs of vines from the fifth bud positions. Comparable vines were planted concurrently in the few remaining spaces. The planting design contained 8, 5, 7, 4; 8, 5, 7, 3; 6, 5, 9, 7; 8, 9, 6, 4 vines from the ninth bud positions on the four pairs selected on sites A, B, C, and D respectively, giving 101 comparisons between vines from high- and low-yielding source vines. The low numbers of some comparisons and particularly of vines from the fifth bud were due to failure of cuttings to root because of unfavourable nursery conditions and not to poor subsequent growth in the field. Planting started in December 1957 and by February 264 vines had been planted. The remaining 24 vines (from various source vines) were planted in spring 1958. Vines were spaced 10 feet apart in rows 11 feet apart and were trained on a two-wire T-trellis.

The propagules were pruned to a maximum of two canes in winter 1958, four canes in 1959 and nine canes in 1960. From then on they were pruned to from six to ten canes each winter according to their vegetative vigour, the number of buds retained on each vine being recorded. To stimulate vegetative growth all inflorescences were removed in October 1958 and their numbers reduced on about one-third of the vines in October 1959. By 1961 an average dried fruit yield of 11 lb per vine (= 2 ton per acre) was obtained.

Yields of fresh fruit from individual propagules were measured each year from 1961 to 1964. The corresponding numbers of bunches were obtained by counting either inflorescences in spring or bunches at harvest. The sugar concentration of a sample of juice was measured with a refractometer. The mean number of berries per bunch was estimated from the mean fresh weight of berries at harvest, determined on a sample of 100 berries per vine for another investigation (ANTCLIFF, unpublished), and the other data. As most sultanas in Australia are dried, yields of dried fruit from individual propagules were calculated from the yields of fresh fruit and sugar concentrations using the baumé-drying ratio curve of LYON and WALTERS (1941). The weight of annual growth removed at pruning and the trunk circumference, six inches above soil level, were also measured annually.

Yields of fresh fruit from the source vines were also measured in 1958, 1962, and 1963 on site A, from 1958 to 1963 on site B, and from 1957 to 1963 on sites C, and D, the vines being still pruned to their pre-selection levels. Yields of dried fruit were not used since sugar concentration was not always measured in the pre-selection period.

All data from the 101 comparisons between bud-9 propagules were examined by analyses of variance. In addition the relation between fresh fruit yields of source vines and the yields and yield components of their respective propagules was estimated by regression analyses using differences in mean yield for all available years within pairs of source vines and differences in mean yield and yield component data for four years within the 101 pairs of propagules. Differences were used rather than absolute values so that data of source vines from different sites would be more comparable.

Data for bud-5 propagules were excluded from these analyses because their yields were lower ($P < 0.05$) than those of bud-9 propagules in 1961 but not in the following years. However yield differences between bud-5 propagules from high- and low-yielding source vines were in accord with those for bud-9 propagules.

Results

Mean yields for the pre-selection period of the four pairs of source vines from each site together with the mean yield and standard deviation of all the vines from which the selections were made are given in Table 1. Yields of the high-yielding vines in the selected pairs were from 30 to 120 per cent greater than those of the corresponding low-yielding vines.

Mean yields and yield component of propagules from the high- and the low-yielding source vines are listed in Table 2. This Table shows that overall there was a higher yield of both fresh and dried fruit of propagules from the high-yielding source vines, and that this was related t● a greater number of bunches per vine and of berries per bunch. The difference in sugar concentration was small, hence the difference in yield of dried fruit corresponded almost exactly with the difference in yield of fresh fruit. The analyses of variance of numbers of buds retained at pruning, of mean pruning weight for 1961 to 1963, and of trunk circumference in 1963 showed no significant differences between propagules from the high- and low-yielding source vines.

However closer analysis indicated that yields of propagules from the high- and low-yielding source vines did not differ equally for all 16 source-vine comparisons, the differences themselves differing significantly. Mean yields of individual pairs of propagules together with mean yields of their respective source vines for all available years are shown in Table 3. In nine of the 16 source-vine comparisons propagules from high-yielding source vines yielded significantly more than those from the corresponding low-yielding source vines. In the other seven comparisons

Table 1

Mean yield of source vines and mean yield for each site during the pre-selection period

Site	Selection	Mean yield (lb fresh fruit per vine)				
		Source-vine pairs				Site mean
		1	2	3	4	
A	High-yielding	34	37	41	36	31 ± 2.2
	Low-yielding	22	16	27	18	
B	High-yielding	50	66	71	61	55 ± 4.3
	Low-yielding	35	34	54	42	
C	High-yielding	41*	39*	49	42	36 ± 5.5
	Low-yielding	30*	28*	36	21	
D	High-yielding	37	51	43	41	31 ± 8.0
	Low-yielding	26	34	27	22	

* These vines were pruned to 7 canes of 14 buds and their yields were adjusted to those expected for 6-cane vines.

Mean yields for site C were estimated from seven years' results and for the other sites from four years' results.

Table 2

Mean yields of high- and low-yielding source vines during the pre-selection period and mean yield data for 1961 to 1964 of their respective propagules

Selection	Source vines	Propagules				
	Fresh fruit (lb per vine)	Fresh fruit (lb per vine)	Bunches per vine	Berries per bunch	Sugar concn. (°brix)	Dried fruit (lb per vine)
High-yielding	46	60	68.1	241	21.01	13.9
Low-yielding	30	48	59.7	221	21.33	11.2
L. S. D.						
P = 0.05	—	5.3	3.5	17	0.31	1.2
P = 0.001	—	9.0	6.1	—	—	2.0

Table 3

Mean yields of source vines and of their respective propagules

Yield differences between the first nine comparisons of propagules were significant.

Selection	Source vines (lb fresh fruit)		Propagules (lb fresh fruit)		Propagules (lb dried fruit)		
	High yielding	Low yielding	High yielding	Low yielding	High yielding	Low yielding	S. E.
C 4	40	19	74	36	16.6	8.5	± 0.67
A 4	33	19*	69	35*	15.4	7.5*	0.89
B 4	52	34	70	47	15.7	10.6	1.02
D 1	32	24*	50	34*	11.4	8.3*	0.63
C 3	46	32	64	44	14.9	10.7	0.59
A 1	32	19	56	41	12.9	9.6	0.63
A 2	31	24	58	43	13.4	9.8	0.79
C 1	38	30	70	56	16.0	12.7	0.72
D 2	38	31	63	51	14.3	11.9	0.59
D 4	39	26*	56	42*	12.7	10.4*	0.89
D 3	38	23*	53	43*	12.1	10.7*	0.72
B 3	63	52	61	54	14.0	12.3	0.67
C 2	41	32	60	57	14.1	13.9	0.79
A 3	37	26	57	59	13.2	13.5	0.67
B 2	54	45	61	64	14.6	15.2	0.79
B 1	42	40	56	58	13.1	13.9	0.63

Source-vine yields were means of 7, 10, 13, and 10 years for sites A, B, C, and D respectively.
Propagule yields were means of 1961 to 1964 inclusive.
* Suscepted virus disease.

yield differences within pairs of propagules were smaller and not significant; in three of these cases propagules from low-yielding source vines slightly outyielded those from the high-yielding source vines. The ratios of yields of each propagule

Table 4

Regression coefficients for differences in mean yield or in mean yield components within pairs of propagules (Y) on differences in mean yield of their respective pairs of source vines (X).

Variable (Y)	Regression Coefficient	S. E.	Significance Level
Mean yield difference	1.25	± 0.18	P<0.001
Mean sugar concentration difference — degrees brix	—0.027	± 0.013	P<0.05
Mean bunch count difference	0.80	± 0.17	P<0.001
Mean berries per bunch difference	2.19	± 0.63	P<0.01

Source-vine yields of fresh fruit (lb) were means of 7, 10, 13, and 10 years for sites A, B, C, and D respectively.
Data from propagules were means of 1961 to 1964 inclusive.

pair to those of their respective source-vine pair were generally similar, particularly so in the first nine cases, and tended to be closer when all seasons' yields for the source vines were used than when only those for the pre-selection period were used.

The regression of differences in mean yield of fresh fruit and in mean yield components within pairs of propagules on differences in mean yield of fresh fruit for all available years within the respective pairs of source vines are given in Table 4. A similar regression for differences in mean berry weight was not significant. These results show a close relationship between yield differences within pairs of source vines and those of their respective propagules and they strongly support the results of the analyses of variance.

The regression of differences in mean yield for 1961 to 1964 within pairs of propagules on differences in their trunk circumference in 1963 and the regression of differences in mean pruning weights for 1961 to 1963 within pairs of propagules on differences in their mean yields were not significant. Furthermore similar regressions for the first nine pairs of propagules with large and significant yield differences listed in Table 3 were not significant.

Discussion

Both analysis of variance and regression analysis showed clearly that yield differences between adjacent sultana vines were reproducible in vines propagated from them. In the analysis of variance propagules from nine pairs out of the 16 tested showed significant differences in yield corresponding to those of their respective source-vines. The regression analysis showed that the differences in yield between the propagule pairs were closely related to the differences in yield between their respective source-vine pairs. This is reflected in the remarkable similarity between the ratios of the yields of each source-vine pair and those of the corresponding propagule pairs for the nine comparisons with significant differences listed in Table 3.

The higher yields of propagules from the high-yielding source vines were mainly due to more bunches per vine or more berries per bunch or both. This is shown in both the analyses of variance and the regression analyses. They were not due to more buds per vine being retained at pruning and there was no evidence that they were related to greater growth or vine vigour. There were no differences in the mean weight of prunings per vine for 1961 to 1963, in the number of buds laid down each year, or in the trunk circumference in 1963 between propagules from the high- and low-yielding source vines. Furthermore the regression of yield differences within propagule pairs on differences in their trunk circumference was not significant; weights of prunings were similarly unrelated to yield differences.

These findings that yield differences in sultanas can be transmissible, while in accord with those of the majority of workers using wine varieties, are directly contrary to those of Bioletti (1926) for Muscat of Alexandria. It is with these that they might most be expected to agree. The explanation for the difference is probably to be sought not in the uniformity of Bioletti's material as suggested by Levadoux (1951) but in the different methods adopted in these experiments. Bioletti selected the high- and low-yielding vines from a field of 1200 vines based on crop records from the second to the sixth harvests and compared the yields of propagules from these vines for their first three harvests. He reported that there was no relation between yields of sources vines and of propagules and that at least the first two crops of propagules were greatly influenced by the size of rootling planted. Thus his source-vine yield differences could well have been due to the initial size of the rootling as well as to environmental factors. In the present work the initial selection was based on yield of vines in full bearing and adjacent vines were selected to minimize environmental effects. Furthermore the method of growing the propagules was designed to minimize initial yield differences due to variations in early development and records were not taken until all vines were in full bearing.

Rives (1961) lists polyclonal origin, virus diseases, and mutations among the causes of variation between vines. With the seedless sultana variation due to polyclonal origin, as has been suggested for Pinot noir and Chasselas doré, would be most unlikely. In the present work virus diseases or mutations or both could be causing the yield variations. Careful inspections during the last two years have revealed that four of the 16 low-yielding source-vines and all their propagules exhibited slight virus-like symptoms of the vein banding type (Goheen and Hewitt [1962]) but that all other source-vines and propagules appeared healthy. All selections are being indexed but no results are available yet. If vein banding is present in the Mildura district it will probably be spread by vegetative propagation only as the nematode vector appears to be absent from these soils (Sauer, private communication). Certainly no evidence of natural spread has been found in the present work. Ampelometric measurements of leaves sampled from propagules from C4, A4, D1, and D3 high- and low-yielding source-vines were made by the method of Galet (1951). All measurements were similar for all selections even though the C4 and A4 propagule comparisons showed the largest differences in yield and vein banding symptoms occurred on A4, D1, and D3 low-yielding selections. Other than for the A4 and D1 comparisons, the low-yielding selections where significant differences occurred (Table 3) could have a symptomless virus disease or could be genetically different without obvious morphological differences. Mutations which do exhibit morphological differences such as Bruce's Sport which has been described by Antcliff and Webster (1962), pink, and tetraploid sultanas have occurred in Australian vineyards.

It follows from the preceding observations that propagation from sultana vines selected for high yields offers a ready means of increasing productivity.

Owing to the difficulty of separating transmissible, environmental or management effects in the source-vine field, high-yielding selections must be evaluated by testing propagules from them in the same environment under field conditions. The problem of reliable selection for high yields is indicated by a comparison of Tables 1 and 3. Omitting the selections showing virus-like symptoms it will be seen that where the largest differences occurred within the propagule pairs the large differences between the corresponding source-vine pairs were similar for the short-term (Table 1) and long-term (Table 3) means, but where yields within the propagule pairs were similar the large differences between their corresponding source-vine pairs tended to disappear with additional years' records. Thus while the short-term period appears adequate for culling out low-yielding vines, potentially high-yielding vines could be omitted if their yields were temporarily low during the test period due to unfavourable management. Even the longer pre-selection period is by no means infallible as local environmental effects can be quite marked. As some of the highest yields in the propagules field were obtained from propagules from source-vines in the lower yielding sites selection of source-vines for highest yields should be made on a vine basis rather than on a site basis.

Summary

Differences in yield transmissible by vegetative propagation have been demonstrated in sultanas in the Murray Valley, Australia. Such differences occurred without obvious differences in vine vigour or obvious morphological differences in vegetation or in fruit.

Four pairs of adjacent sultana vines which had shown large differences in yield within pairs for four or seven years were selected from about fifty uniformly pruned vines on each of four vineyards. Vines propagated from these pairs showed corresponding and statistically significant differences in yield over four years in nine out of sixteen cases and in no case was there a significant difference opposite to that originally selected.

The higher yields of the vines propagated from the higher-yielding vines of the selected pairs were mainly due to more bunches per vine or bigger bunches or both. Measurements of trunk circumference and weight of prunings suggested that they could not be ascribed to greater vegetative development.

Although the presence of virus has not yet been confirmed, slight virus-like symptoms have been observed on four of the low-yielding selections and the vines grown from them. The other 28 selections and the vines grown from them have shown no sign of such diseases nor of any morphological differences between them.

Whatever the reason for the differences it is clear that selection for yield should be valuable in increasing productivity of sultanas in Australia.

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