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The effect of grapevine leafroll plus yellow speckle disease on annual growth, yield and quality of grapes from Cabernet Franc under two pruning systems

by

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Holzproduktion sowie Traubenertrag und -qualität von Cabernet Franc bei kombinierter Einwirkung von Leafroll und Yellow speckle disease in Verbindung mit zwei verschiedenen Anschnittsystemen

Zusammenfassung. — Zwei Kombinationen von Leafroll mit Yellow speckle disease wurden von den beiden ertragsstarken Sultana-Klonen H4 und H5 auf die Sorte Cabernet Franc, die auf Zapfen und auf Bogreben angeschnitten war, übertragen. Der Einfluß der Infektion auf die Leistungsfähigkeit dieser Sorte wurde über einen Zeitraum von 6 Jahren verfolgt.

Im Durchschnitt der 6 Jahre war nach der Krankheitsübertragung von den Infektionsquellen H5 und H4 das Gewicht des jährlich produzierten Holzes um 21 bzw. 15 %, der Traubenertrag (Frischgewicht) um 9 bzw. 6 % und die Mostzuckerkonzentration um 0,6 bzw. 0,3 °Brix verringert. In einigen Jahren waren auch die titrierbare Säure und das pH des Mostes leicht verändert. Die Anzahl der Infloreszenzen und das mittlere Beerengewicht wurden durch keine der beiden Viruskombinationen beeinflußt.

Im Vergleich zu den auf Zapfen geschnittenen Reben zeigte Cabernet Franc bei Bogrebenschnitt im Mittel von 4 Jahren einen verringerten jährlichen Holzzuwachs (21 %), stetig abnehmenden Traubenertrag (16 %, bezogen auf Frischgewicht) und leichtere Beeren (9 %); die Anzahl der Infloreszenzen und der Zuckergehalt wurden durch den Anschnitt von Jahr zu Jahr uneinheitlich beeinflußt; ein Einfluß auf Säure und pH des Mostes lag nicht vor. Auf Bogen geschnittene Reben hatten einen deutlich erniedrigten und stärker schwankenden Beerenansatz. Innerhalb eines Schnittsystems wirkten sich die unterschiedlichen Virusherkünfte jedoch nicht merklich auf den Beerenansatz aus.

Es wurde eine langsame natürliche Ausbreitung von Yellow speckle, aber nicht von Leafroll nachgewiesen.

Introduction

Indexing for grapevine virus[2]) diseases in Australia has shown that many vines contain multiple graft-transmissible diseases and that a common combination is leafroll plus yellow speckle (WOODHAM *et al.* 1973). These two diseases are present in all our high-yielding selections of Sultana (syn. Thompson Seedless, Sultanina) but the economic importance of the complex is not known. This paper reports an assessment of the combined infection when experimentally introduced into Cabernet Franc. This wine cultivar, grown widely in France, is now attracting interest in Australia. Because there is no information on the training of Cabernet Franc in Australian irrigated environments, and to test a possible interaction between virus and pruning system, two pruning treatments, spur- and cane-pruned, were included.

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[2]) Virus refers to known viruses and to graft-transmissible diseases of unknown etiology.

Materials and methods

A Cabernet Franc clone, A. C. 72.8186 (IKIN 1980), which is routinely included in our virus indexing was used as the test plant. Two high-yielding Sultana clones infected with leafroll and yellow speckle were used as the virus inoculum sources; these clones were H5 and H4 (ANTCLIFF and HAWSON 1974).

Newly rooted cuttings of Cabernet Franc were graft inoculated in spring 1971 with a dormant chip-bud from H5 or H4. After 2 months in a glasshouse they and similar uninoculated cuttings were planted in a field nursery. Union of the inoculum-chip was recorded 4 months after grafting, and the buds were removed to prevent subsequent growth of Sultana. Successfully inoculated vines and uninoculated vines were planted in spring 1972 on the Division's farm at Koorlong in soil classified as Dareton sand which has been described by NORTHCOTE (1951). The area was irrigated by overhead sprays and weeds were controlled by cultivation. Nitrogen (sulphate of ammonia or urea) was broadcast annually at the rate of 22 kg nitrogen/ha before irrigations in early spring and again in early summer. In an attempt to obtain optimum fruit-set in harvests 1980—1982, a suspension of zinc sulphate was applied as a foliage spray (ALEXANDER and WOODHAM 1964) to all measured vines at the first sign of flowering. To provide a visual comparison the guard vines were not sprayed.

Experimental layout

The vines were planted 2.4 m apart in 2 parallel rows 3.0 m apart, and were trained on a 1.3 m high, 0.4 m T-trellis; each row was 6.1 m from previously planted vines. Each row contained 13 plots of 3 vines with 2 guard vines at each end. The two pruning treatments, spur-pruned (SP) and cane-pruned (CP), were randomised in pairs of plots across the rows. The three virus treatments, Cabernet Franc inoculated with H5 (H5) or with H4 (H4) and Cabernet Franc uninoculated (Control), were randomised within each plot in each row. Thus the experiment was a randomised block (6 vines) split-plot design with the pruning treatments forming the main plots and the virus treatments the sub-plots.

Growth and virus observations

In the initial years the vines were trained according to their method of pruning and 4 permanent arms were formed on SP vines. We used 2-bud spurs and canes adjusted to 15 or 14 buds long, respectively. In spring 1974 most inflorescences were removed to promote vegetative growth. The numbers of buds retained per vine annually were adjusted as follows: 48 buds for SP vines and 60 (4 canes) for CP vines harvested in 1976; 72 and 90 (6 canes) respectively for harvest 1977; 88 and 112 (8 canes) respectively for harvest 1979 and thereafter.

The weight of annual growth pruned from each vine in winter was recorded and used as a measure of growth for the preceding growing season. The weight for CP vines included an estimate for the canes retained. In each year all controls were pruned first to avoid possible contamination from the infected vines. All vines were inspected each autumn for leaf symptoms associated with leafroll and with yellow speckle diseases.

Crop observations

The growing season which covers parts of 2 calendar years is named by the year of harvest. The number of inflorescences per vine was counted in spring, and the weight of fresh fruit was measured from harvest 1976. Each year we attempted to harvest when the grapes had reached optimum maturity as estimated from sugar, pH and acid-

ity measurements of weekly samples from the guard vines. To determine mean berry weight and sugar concentration (° Brix), pH and titratable acidity (g/l as tartaric acid) of the juice, 100 berries/vine, 5 from each of 5 bunches selected at random from each quarter-segment of the vine, were sampled at harvest. Data were not obtained in 1978 because a hail storm in October destroyed most of the inflorescences. As cane pruning was markedly inferior to spur pruning in the first 4 harvests, data thereafter were obtained from only SP vines.

The respective measurements were subjected to analyses of variance.

Results

Typical symptoms of leafroll and of yellow speckle were induced in all Cabernet Franc vines inoculated with each source of Sultana by the 2nd autumn (1973) after grafting, thus indicating successful transmission of the agents of both diseases. Leafroll symptoms invariably occurred thereafter; in each autumn the symptoms on H4-inoculated vines were clearly milder than those on H5-inoculated vines. In some years initial symptoms of leafroll were noted at harvest. No control vines expressed leafroll symptoms in any year. Yellow speckle symptoms were obvious on all inoculated vines again in autumn 1974, 1978, 1979 and 1981, but the symptoms were much milder and not observed on all vines in the other years. Yellow speckle symptoms were

Table 1

A comparison of the effects of spur- and cane-pruning on yield components and annual growth of Cabernet Franc over 4 years

Vergleich des Einflusses von Zapfen- und Bogenschnitt auf die Ertragskomponenten und auf die Holzproduktion bei Cabernet Franc im Verlauf von 4 Jahren

Pruning	Harvest year				LSD[1])
	1976	1977	1979	1980	P = 0.05
Fresh fruit yield/vine (kg)					
Spur	12.5	19.7	20.1	18.7	1.54
Cane	11.0	17.3	16.7	14.3	
No. of inflorescences/vine					
Spur	119	156	181	199	9.0
Cane	113	168	180	150	
Mean berry weight (g)					
Spur	1.29	1.25	1.22	1.14	0.04
Cane	1.22	1.10	1.10	1.04	
Sugar concentration (° Brix)					
Spur	21.55	17.46	21.07	23.00	0.32
Cane	21.56	17.05	20.40	22.74	
Weight of prunings/vine (kg)					
Spur	2.50	2.29	2.75	2.14	0.34
Cane	2.25	1.56	2.26	1.63	

[1]) LSD is a mean value for comparison within years.

observed on 2 of the 26 control vines in 1978 and they recurred on these 2 vines in subsequent years of good expression. However, no other controls showed yellow speckle symptoms in any year.

Pruning treatments

The effects of the 2 pruning systems on yield components and weight of prunings of Cabernet Franc vines are given in Table 1. As significant interactions were present between years and pruning treatments for most variables, the treatment means

Table 2

The effects of two combinations of leafroll plus yellow speckle diseases on yield, grape quality, and annual growth of Cabernet Franc over 6 years · The virus inoculum sources were high-yielding Sultana clones H5 and H4 · In 1981 and 1982, data were measured on spur-pruned vines only

Der Einfluß zweier Kombinationen von Leafroll mit Yellow speckle disease auf Traubenertrag und -qualität sowie auf die Holzproduktion bei Cabernet Franc im Verlauf von 6 Jahren · Als Virusquellen dienten die ertragsstarken Sultana-Klone H5 und H4 · 1981 und 1982 wurden nur bei den auf Zapfen geschnittenen Reben Werte gemessen

Virus treatment	Harvest year					
	1976	1977	1979	1980	1981	1982
Fresh fruit yield/vine (kg)						
Control	12.1	19.3	19.9	18.3	17.9	23.9
H5	11.4	17.5	17.6	15.4	16.7	22.3
H4	11.7	18.6	17.7	15.8	17.7	22.7
LSD[1]) P=0.05	NS	1.34	1.18	1.28	NS	NS
Sugar concentration (° Brix)						
Control	21.89	17.53	20.95	23.27	24.28	23.61
H5	21.16	17.08	20.41	22.57	23.73	22.84
H4	21.62	17.16	20.84	22.78	23.90	23.46
LSD P=0.05	0.24	0.32	0.23	0.29	0.27	0.38
Titratable acidity of juice (g/l as tartaric acid)						
Control		5.76	4.98	5.85	3.60	4.05
H5		5.88	5.32	6.19	3.81	4.19
H4		5.86	5.16	6.15	3.78	4.10
LSD P=0.05		NS	0.17	0.12	0.08	0.08
pH of juice						
Control		3.50	3.55	3.42	3.95	3.88
H5		3.49	3.52	3.40	3.91	3.82
H4		3.48	3.54	3.39	3.87	3.86
LSD P=0.05		NS	0.02	0.02	0.04	0.04
Weight of prunings/vine (kg)						
Control	2.74	2.22	2.88	2.10	2.75	2.68
H5	2.11	1.72	2.31	1.70	2.30	2.03
H4	2.27	1.82	2.33	1.86	2.45	2.29
LSD P=0.05	0.35	0.25	0.33	0.22	NS	0.38

[1]) LSD for comparison within years. NS = not significant.

(a mean of the three virus treatments) for each year are presented. The least significant differences were quite consistent from year to year, thus a single pooled value for each variable is given.

In comparison with SP vines the CP vines yielded less in each of the 4 years, the reduction increased with time with a mean annual decrease of 16 %. The large decrease in yield 1980 was due to 25 % fewer inflorescences. Cane pruning decreased berry weight in each year, and slightly reduced sugar levels (by about 0.5 °Brix) in 2 years but did not affect titratable acidity or pH of juice. Annual growth was less on CP vines in 3 years, the decrease ranged from 18—32 % with a mean of 25 %. However, in winter 1977 and 1980 sufficient canes of good quality were still available for the selected pruning level of 112 buds.

Inspections at each harvest revealed that fruit-set on SP vines was clearly superior to that on CP vines. On most SP vines at least 75 % of the bunches were compact and dense with relatively even-sized berries whereas all CP vines showed considerable variability in set and size of berry; on several CP vines 50 % of the bunches would be quite straggly with fewer and smaller berries of a variable size. However, no differences in fruit-set between virus treatments within either pruning method were detected. Observations of fruit-set on SP and CP vines sprayed with zinc and on corresponding unsprayed guard vines showed that zinc did not visibly improve fruit-set.

Virus treatments

Effects of both virus sources on yield, grape quality, and pruning weight of Cabernet Franc vines are shown in Table 2. As there were significant interactions between years and inocula for most variates but not between virus and pruning systems, the treatment means (a mean of both pruning methods) for each year together with appropriate least significant differences are given.

Yield of fresh fruit was reduced by both inoculum sources in 1979 and 1980, and by only H5 in 1977; the similar trends but smaller differences in other years were not significant. Both the inflorescence number and mean berry weight were unaffected by either source. Sugar concentration of the juice was reduced by H5 each year (by a mean of 0.6 °Brix), and by H4 in 4 years by a smaller magnitude; H5 was significantly less than H4 in 3 harvests. The titratable acidity of juice from H5 vines exceeded the control in 4 of 5 harvests while H4 vines were higher in 3 of these years, whereas corresponding pH values were less than the control in 4 and 2 harvests respectively. However, the increase in acidity and decrease in pH were quite small. The weight of annual growth was reduced by both sources in 5 of 6 years. The mean decrement of 21 % by H5 was larger than that by H4; however, the differences between H5 and H4 were not significant.

Discussion

Cabernet Franc was chosen as the test plant because a Sultana clone free of both leafroll and yellow speckle was not available; also, it is our best indicator of leafroll and the equal of other cultivars we use to detect yellow speckle. The clone used was free of grapevine fanleaf virus and of leafroll, yellow speckle, fleck, corky bark, summer mottle and enation diseases, but had not been indexed for vein necrosis and stem pitting. These nine virus diseases have been detected in vines growing in Australia. Both Sultana clones, co-infected with leafroll and yellow speckle, were free of the other seven

diseases. Neither H5 or H4 express the typical "green vein" symptoms of leafroll depicted by UYEMOTO *et al.* (1978), but in late autumn of some years they may show a yellowish blotching of near basal leaves which we now consider to be associated with relatively mild leafroll strains. Both clones induce leafroll symptoms always in Cabernet Franc, irregularly and inconclusively in LN33, but never in Mission or Baco 22A.

With the pruning levels used in this trial, spur pruning of Cabernet Franc, independent of virus treatment, was obviously superior to cane pruning.

The two combinations of leafroll and yellow speckle caused larger depressions in annual growth than in the yield components and grape quality of Cabernet Franc. The yields of vines inoculated with H5- or with H4-sources were less than control vines each year, but the differences reached statistical significance in only 3 and 2 years respectively. The reductions in sugar content and the variations in titratable acidity and pH of the grape juice indicate that virus delayed maturity even though causing smaller yields. However, the magnitude of these differences in grape quality would not be important in commercial winemaking.

Clone H5 induced leafroll symptoms more severe than H4, tended to depress annual growth and yield more than H4, and in 3 of 6 years reduced sugar concentration significantly more than H4; these findings suggest that H4 could be a better Sultana clone for commercial plantings. It is interesting that although the differences in any one trial were not statistically significant H4 slightly outyielded H5 in three large clonal trials reported by ANTCLIFF and HAWSON (1974). Our findings indicate that any possible difference between H5 and H4 would be due to a graft-transmissible factor.

The large variability between years in the severity of yellow speckle leaf symptoms on Cabernet Franc is a characteristic of the disease (KRAKE and WOODHAM 1983). The detection of yellow speckle symptoms on 2 of 26 control vines indicated a low incidence of natural spread of the disease agent in an unknown way (WOODHAM and KRAKE 1982). However, there was no evidence of leafroll spreading naturally.

Although the cause of these decrements by virus cannot be assigned to either leafroll or yellow speckle alone and it cannot be assumed that the complex would induce similar effects in healthy Sultana, it seems reasonable to predict that any decrease in yield or growth of Sultana would be smaller than that caused by strains of leafroll that induce typical "green vein" symptoms in that cultivar (WOODHAM, unpublished).

Summary

The effects of two combinations of grapevine leafroll plus yellow speckle disease in two high-yielding Sultana selections (H4 and H5) on the performance of Cabernet Franc under two pruning methods were determined over 6 years.

When averaged over the 6 years, H5 and H4 reduced the weight of annual growth by 21 % and 15 %, decreased the yield of fresh fruit by 9 % and 6 %, and depressed the sugar concentration of juice by 0.6 and 0.3 °Brix respectively. The titratable acidity and the pH of juice were slightly affected in some years. The number of inflorescences and mean berry weight were not affected by either virus source.

When compared with spur pruning and averaged over the 4 years, cane-pruned vines produced less annual growth (21 %), progressively less fresh fruit (16 %), and had lighter berries (9 %), but effects on the numbers of inflorescences and sugar content were inconsistent between years; the acidity and pH of juice were not affected. Cane-

pruned vines had obviously inferior and more variable fruit-set. However, no visible differences in fruit-set due to the virus sources within each pruning method were detected.

There was evidence of a low incidence of natural spread of yellow speckle, but not of leafroll.

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