Vitis 5, 1—9 (1965)

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A Comparison of Cropping Levels in the Sultana

by

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Introduction

The value of an estimate of fruiting potential to sultana growers in the Murray Valley, Australia, has been discussed by May (1961). Such an estimate, now made annually, is designed to help reduce the very great fluctuations in yield from year to year by allowing pruning level to be adjusted to yield potential. The extent to which this aim can be achieved is limited not only by the effect of other factors influencing crop as described by May (loc. cit.) but also by the degree to which the vine will respond to any variation in pruning level which can be used in practice.

Antcliff, Webster, and May (1956) described a pruning experiment in which sultanas were pruned to varying numbers of canes, the canes themselves having equal numbers of buds, to study the effect of pruning treatment on many aspects of vine growth and yield, and discussed the results in relation to the problem of obtaining even yields from season to season. They concluded that by regulating the number of canes retained at pruning to the fruiting potential it was possible to avoid overcropping in very fruitful seasons and to improve the crop in seasons of low fruitfulness but that vine response to variation in pruning was too small for complete uniformity of crop from year to year to be achieved even if all other conditions remained constant.

This work has been continued and the findings of the earlier paper can be extended, particularly with regard to the level of cropping which can be considered overcropping. Serious effects of overcropping have been described for some vine varieties in California (Winkler 1954, Weaver and McCune 1960), and some of the results of Antcliff, Webster, and May (1956) suggested the possibility of overcropping. The greatest number of canes retained in any of their treatments was 10 and the 10-cane vines always carried less crop than the 9-cane vines for the three years in which these treatments were included. Although there was no significant departure from a linear relation of crop to cane number it seemed possible that with more canes such an effect might be found. In further trials pruning to 6, 8, 10 or 12 canes has been compared, and since the earlier trial was on only one site this has been done on another three sites, two with younger vines in the Robinvale district about 50 miles from the original site and one with older vines at Red Cliffs about 10 miles from the original site.

Observations and Results

Further results from the original experiment

The original experiment was in two parts, in one of which all vines were pruned alike after three years to look for residual effects from the previous pruning treatments. In the other part 25 vines were pruned to each of 3, 4, 5, 6, 7 or 8 canes each season from 1950-51 to 1955-56. There were differences in the way yield increased

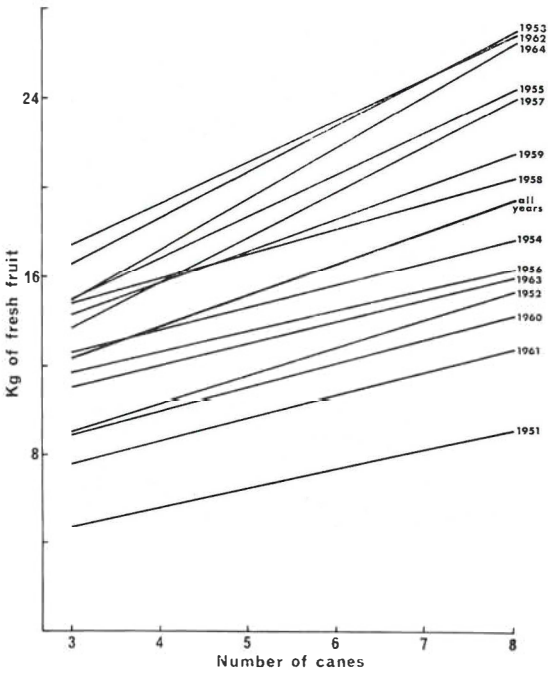

Fig. 1

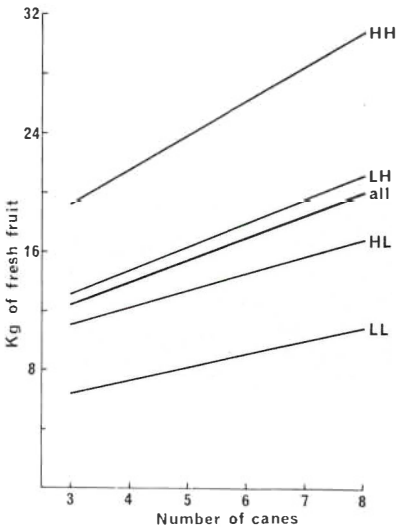

Fig. 2

Fig. 1: Regressions relating yield of fresh fruit harvested to number of canes retained at pruning, 1950-51 to 1933-64.

Fig. 2: Regressions relating yield of fresh fruit harvested to number of canes retained at pruning for selected vines and seasons.

HH high yielding vines in seasons of high yield
LH low yielding vines in seasons of high yield
HL high yielding vines in seasons of low yield
LL low yielding vines in seasons of low yield

with increasing cane number between the first three and the last three of these seasons which suggested a possible cumulative effect of the pruning treatments so these have now been continued for a further eight seasons. Yields of fresh fruit have been taken for each vine in each season and sugar concentration has been determined with a refractometer on the juice from a sample of berries from each vine in four of the eight seasons.

Figure 1 summarises the data for yields of fresh fruit for the whole 14 seasons. It takes the form of a series of linear regressions fitted to the treatment means for each season together with a further regression fitted to the treatment means for the whole period. These regressions were all significant at the 0.1% level and none left any significant deviations.

In every year larger yields of fresh fruit were obtained when more canes were left per vine but there were very highly significant differences between the slopes of the regression lines. A greater increase in yield with increasing number of canes when the general yield for the season was greater appeared to be a likely explanation. The correlation between the slope of the regression line and the mean yield

for the whole 150 vines each season was indeed significant at the 0.1% level but although this was the major factor differences significant at the 1% level between the regressions remained after it was allowed for. These differences appeared to be connected with a slight biennial bearing effect. In a season following a very heavy crop the slope of the regression line tended to be less than might otherwise have been expected (e. g. 1954) while in a season following a light crop the regression tended to be steeper than might otherwise have been expected (e. g. 1952). There was no suggestion of a cumulative effect since the steepest slope, even for a heavy crop, occurred in 1964 after 14 years of differential pruning.

No significant differences in sugar concentration were found in any of the seasons when determinations were made. This applied even in 1964, after 14 years of the treatments, when there was a heavy crop and yield increased most with increasing cane number. The results found for yield of fresh fruit would therefore also apply to yield of dried fruit.

When the yields of the individual vines were compared over the whole period of the trial very highly significant differences were found independent of the effect of pruning treatment. The lowest yielding 3-cane vine had a mean yield of 7.4 kg over the 14-year period and the highest yielding a mean of 16.2 kg, while for the 8-cane vines the corresponding values were 12.3 and 23.6 kg. Such differences, which were far larger than those between treatment means, were not solely associated with positional effects since for example, two adjacent 6-cane vines had mean yields of 9.0 and 18.2 kg. A difference of 4.9 kg between such means within treatments was sufficient for significance at the 0.1% level .

In view of these large differences within treatments the data for the four consistently highest yielding vines and the four consistently lowest yielding vines within each treatment (measured over the whole 14 years) were extracted for three years of high yield (1953, 1962, 1964) and for three years of low yield (1952, 1960, 1961) and analysed separately. Figure 2 summarises the results as a series of linear regressions relating yield of fresh fruit to number of canes retained at pruning. These regressions were again significant at the 0.1% level with no significant deviations. The differences between the four individual regressions, for either high or low yielding vines in seasons of either high or low yield, were significant at the 1% level and these differences were entirely accounted for by the correlation between the slope of the regression lines and the corresponding means of the yields for all pruning treatments.

Thus, over the range studied, the greater the yield capacity of the vines the greater the increase in yield as more buds were left at pruning, and this effect was the more pronounced the more fruitful the season. The lightest pruned high yielding vines produced at an average rate of about 13½ tons of fresh fruit per acre in the three seasons of high yield, and there was no evidence from the sugar determinations made in two of these seasons that this was accompanied by later maturation or lower sugar concentration.

Results from other sites

The trials on the other three sites, two at Robinvale with 440 vines per acre and one at Red Cliffs with 403 vines per acre, were all of the same design. An area of 40 vines, made up of ten vines in each of four trellis rows, was divided into ten plots across the rows and four pruning treatments assigned at random within each plot. The treatments were pruning to leave 6, 8, 10 or 12 canes per vine, as far as

possible all of 14 buds each and where this was not possible with a mean of 14 buds per cane. These treatments were continued for four seasons, from 1958-59 to 1961-62, and then in 1962-63 all vines were pruned, as nearly as possible, to twelve 14-bud canes. Each spring per cent. bud burst and per cent. fruitful shoots as defined by ANTCLIFF and WEBSTER (1955) were determined for each vine and at each harvest the yield of fresh fruit and the sugar concentration in a sample of juice were measured. The results obtained are shown graphically in Figures 3 and 4.

The results for yield of fresh fruit during the seasons of differential pruning are summarized in Figure 5. They are shown as linear regressions of yield on number of canes retained, firstly for the three sites combining all seasons and secondly

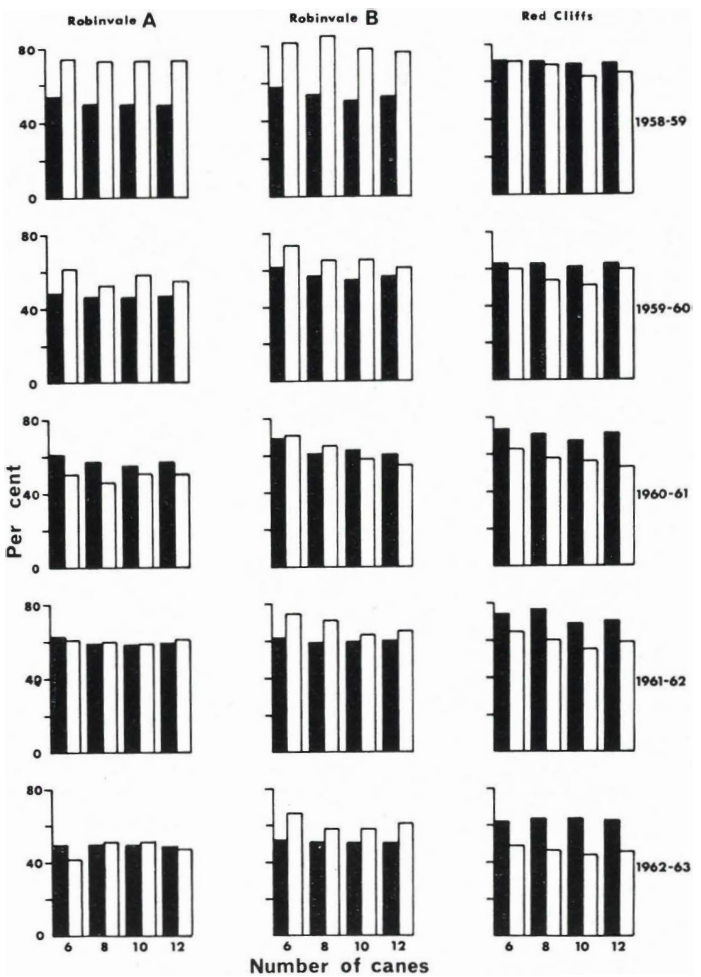

Fig. 3: Per cent. bud burst (black) and per cent. fruitful shoots (open) for four pruning treatments on three sites in five seasons.
In 1962-63 all vines were pruned to 12 canes and the number of canes shown refers to the number of canes previously left on the vines.

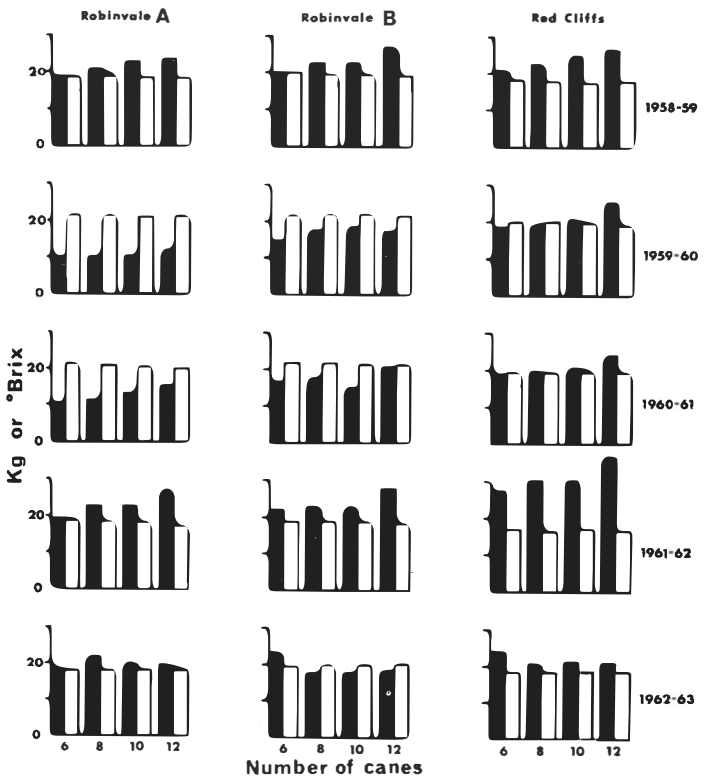

Fig. 4: Weight of fresh fruit harvested (kg, black) and sugar concentration in a sample of juice (°Brix, open) for four pruning treatments on three sites in five seasons. In 1962-63 all vines were pruned to 12 canes and the number of canes shown refers to the number of canes previously left on the vines.

for the four seasons combining all sites. The overall regression for all sites in all seasons is also shown in both cases. This was significant at the 0.1% level and left no significant deviations. There was no interaction between treatments and either seasons or sites and it is quite clear that over this range of pruning levels also the yield of fresh fruit increases as more canes are retained. There was no indication that the increase was less for the greatest number of canes and, in fact, the mean yield was in every case higher for the 12-cane vines and lower for the 10-cane vines than the values shown on the regression lines. This effect, which was not strong enough to cause significant deviations from the regressions, may have been connected with consistent differences between vines independent of treatment as these were again present and very highly significant.

Differences in sugar concentration were small and rarely significant so that the results for yield of fresh fruit would apply also to yields of dried fruit.

In the final season when all vines were pruned alike there were no significant differences in either yield or sugar concentration related to the previous pruning treatments. This was a season of below average yield and followed a season of above average yield, a sequence which should have been favourable to showing up any effects of previous cropping.

Table 1

Yield of fresh fruit and sugar concentration in a sample of juice for the highest and lowest yielding vines in the 12-cane treatment on the Red Cliffs site.

Season	High yielding vine		Low yielding vine	
	Weight (kg)	Sugar (°Brix)	Weight (kg)	Sugar (°Brix)
1958-59	40.1	17.2	13.7	19.5
1959-60	24.7	20.4	20.7	19.5
1960-61	24.0	20.6	24.5	18.8
1961-62	54.8	15.8	26.8	16.5
1962-63	31.3	18.6	13.4	19.4

That there was little evidence of overcropping can be illustrated by the results for the consistently lowest and highest yielding vines in the 12-cane treatment on the Red Cliffs site (Table 1). It can be seen that although the high yielding vine yielded nearly three times as much as the low in 1959 and more than twice as much in 1962, the two seasons of high yield, it also yielded more in the succeeding year in each case, more than twice as much in 1963. And although, to accommodate the grower concerned, the fruit had to be harvested before maturity each year the differences in sugar concentration gave little support to any suggestion of overcropping. The yield of the high yielding vine in 1962 was equivalent to nearly 22 tons of fresh fruit per acre; the mean yield of all 12-cane vines on this site in this season was equivalent to about 14¾ tons per acre.

For per cent. bud burst in the four seasons of differential pruning there were highly significant differences between pruning treatments and also between seasons but the interaction between seasons and treatments was completely non-significant. The effect of pruning treatment on bud burst did not differ between the 1958-59 season, immediately after the treatments were first applied, and the other three seasons, when there was also a difference in crop between the treatments in the previous season. On the other hand in the final season, when all vines were pruned alike, there were no significant differences in bud burst related to the previous pruning treatments despite their effect on the crop in the preceding season. In the seasons when the vines were pruned differently the main effect was a higher per cent. bud burst in the six-cane treatment, with much smaller differences between the others, the twelve-cane having in fact a slightly higher value than the ten-cane. The trend could be described by a very highly significant quadratic regression, which is shown in Figure 6.

The results for per cent. fruitful shoots were very similar to those for per cent. bud burst. For the four seasons of differential pruning there were again highly significant differences between treatments and between seasons with no interaction and in the final season when all vines were pruned alike there were again no significant differences related to previous treatment. Also the major difference in the first four seasons was again between the six-cane and the other treatments and a quadratic regression described the trend very accurately, although in this case the quadratic term was not significant even at the 10% level. This regression is also shown in Figure 6.

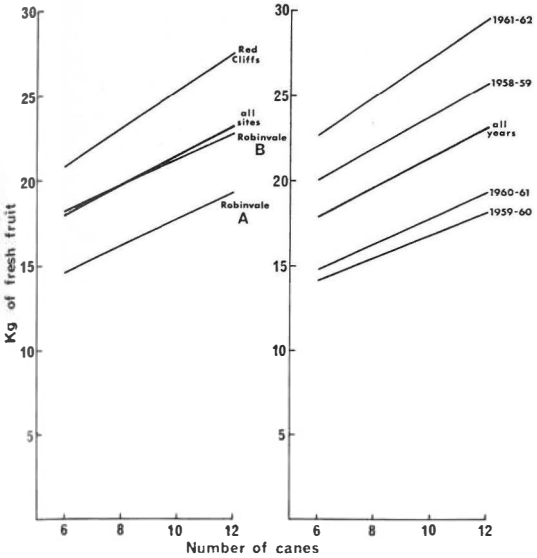

Fig. 5: Regressions relating yield of fresh fruit harvested to number of canes retained at pruning. Left, for three sites combining four seasons. Right, for four seasons combining three sites.

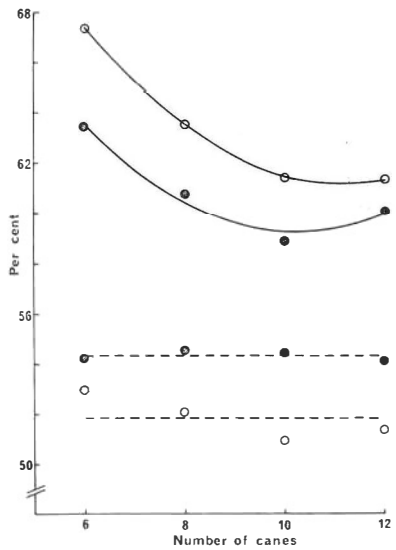

Fig. 6: Per cent. bud burst (full circles) and per cent. fruitful shoots (open circles) for four seasons of differential pruning (combined, full lines) and a final season when all vines were pruned alike (dashed lines).

The very close resemblance between the two curves appears to be more than coincidental. The differences in bud burst and fruitfulness between the various sites and seasons were not in step, but within each site in each season they did tend to be related. On calculating the regression of fruitfulness on bud burst for the treatment means in each case it was found that there were no significant differences between the individual regressions and that the average regression for all sites and seasons with the effect of differences between sites and seasons eliminated was very highly significant, the corresponding correlation coefficient being 0.604 with 35 degrees of freedom.

Thus it appears, that the effect of pruning treatment on fruitfulness was related to its effect on bud burst. Taken in conjunction with the absence of differences in the final year when all vines were pruned alike this suggests that the lower proportion of shoots which carried inflorescences when more canes were retained was at least partly due to the corresponding reduction in bud burst being mainly of buds which would have produced fruitful shoots.

A comparison of bud burst and fruitfulness at individual bud positions along the cane showed that the differences due to pruning treatment were not at any particular position but were general over the whole length of the cane.

Discussion

The main conclusion to be drawn from the present work as compared with the earlier work of Antcliff, Webster and May (1956) it that the danger of overcropping

of sultanas in the Murray Valley is not as serious as was thought. It was suggested that the number of canes to be retained at pruning should range from all available in years of very low fruitfulness through about ten in average years down to about seven in years of very high fruitfulness. It would now appear that there is no need to reduce the number of canes in seasons of high fruitfulness on the grounds of possible damage to the vines through overcropping. Limitation of the crop in such seasons could be considered for other reasons, such as restricted capacity of the growers' equipment at harvest or possible marketing difficulties, but in view of the many hazards which can reduce yield this may not be desirable. There seems to be no reason why a crop of say 15 tons per acre of fresh fruit on sandy loam soils such as those on which the trials were situated should not be aimed at each year with the understanding that only in favourable seasons will it be realised. If the consistent differences in yield between individual vines proved to be due to internal factors and the lower yielding vines could be eliminated a further increase in the target to perhaps 20 tons per acre might be possible.

The variation from year to year in fruit bud formation, yield and maturation appears to be due far more to variation in climatic factors than to previous cropping. ANTCLIFF (1955) has already shown that crop has only a minor effect on fruit bud formation and the present work confirms this; BALDWIN (1964) has shown that there is a very close relation between hours of bright sunshine at a particular critical period and fruit bud formation and MAY and ANTCLIFF (1963) have confirmed this by experimental shading. Only a slight effect of previous cropping on yield was detected in the present work; MAY (1961) has discussed how yield is affected by bud fruitfulness and also directly by conditions during the growing season and BALDWIN (unpublished data) has found that yield is closely related to temperatures at and shortly after flowering. The differences in sugar concentration related to pruning treatments were very small compared to the differences between seasons so that over the range studied cropping seems to have only a minor effect on maturation. It seems likely that some of the effects attributed to overcropping by WINKLER (1954) were in fact due to seasonal variation in climatic factors.

The relatively small adjustment in yield that is possible from variation in pruning level is clearly shown by the results. Over the 14 years of the first trial 3-cane vines gave nearly two-thirds of the yield given by 8-cane vines and in the later trials 6-cane vines gave more than three-quarters of the yield given by 12-cane vines.

Summary

When sultana vines were pruned to from three to eight 14-bud canes each year for 14 years there was in every season a linear relation between number of canes retained and weight of fresh fruit harvested. The increase in weight per cane retained was positively correlated with the overall mean yield for the season but there were departures from this relation suggestive of a slight biennial bearing effect. No evidence was found of any cumulative effect of the differential pruning. The yield from three-cane vines over the whole period was nearly two-thirds that from eight-cane vines.

Smaller experiments on three sites comparing pruning to 6, 8, 10 and 12 canes per vine showed that a linear relation between number of canes and weight of fresh fruit also held over this range for the four seasons studied, with no interaction between pruning treatment and site. The yield from six-cane vines was more

than three-quarters that from twelve-cane vines. The percentage of buds which burst and the percentage of these which were fruitful appeared to be affected by the pruning level directly and not through its effects on crop.

In both cases there were significant differences in yield between individual vines within the pruning treatments over the period of the trials and these appeared to be at least partly due to internal factors in the vines.

No evidence of overcropping was found up to a yield of 14¾ tons per acre, the highest for any of the treatments tested.

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Eingegangen am 26. 2. 1965

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