

## Fruitfulness in grape-vines: The response of different cultivars to light, temperature and daylength

by

M. S. BUTTROSE

### Introduction

Some effects of light intensity and temperature (3), and daylength (4) on the fruitfulness of one cultivar of grape-vine, Muscat Gordo Blanco, have been described. The fruitfulness of buds on shoots 13 weeks after bud-burst increased from zero at 20° C up to a maximum close to 35° C, and fell rapidly at higher temperatures. With 16-hour days, fruitfulness increased with increasing light intensity over the range 900—3600 foot candles (f. c.). Fruitfulness was related to the total number of hours of high-intensity light given per day, but was not influenced by the duration of low-intensity light given in addition, nor by the length of uninterrupted dark periods.

Vines of the species *Vitis vinifera* L. grow and bear fruit between the equator and latitude 50° (8), though grape-growing is mainly confined between latitudes 20° and 50°. Thus vines grow over a fairly wide range of conditions of light, temperature and daylength. Choice of cultivar in commercial plantings is to some extent associated with climate: for example, Rhine Riesling is typical of the cooler vine-growing areas, whereas Sultana (Thompson Seedless) and Ohanez are grown only in warmer areas. It is of interest to learn whether various *V. vinifera* cultivars are similar to Gordo in the response of fruitfulness to factors of the environment, and this paper describes growth cabinet experiments done to provide some information.

### Materials and Methods

The cultivars of grape-vine investigated were:

1. Muscat Gordo Blanco (syn. Muscat of Alexandria),
2. Rhine Riesling,
3. Shiraz (syn. Syrah),
4. Ohanez (syn. Almeria),
5. Sultana (syn. Thompson Seedless, Sultanina).

Plants were established from dormant hardwood cuttings and maintained in growth cabinets as described previously (2). Environmental conditions for an experiment were set at bud-burst, and buds which developed on main shoots were examined, by dissection, for fruitfulness at 13 weeks after burst (3). In one experiment with Sultana, buds were examined after 26 weeks at 3600 f. c., 25° C. Effects of temperature were examined by growing at 15°, 20°, 25°, 30° and 35° C for 16-hour days (3600 f. c.), with a 5° drop for night temperature. Effects of light intensity were examined by growing at 900, 1800 and 3600 f. c. for 16-hour days at 25° C (20° C nights). Daylength was manipulated in two experiments as listed in Table 2. For Gordo and Sultana there were 20 replicates (plants) for each environmental condition, and for the remaining three cultivars there were 8 replicates for each.

In this paper the term fruitfulness refers to the mean number of bunch primordia found per bud.

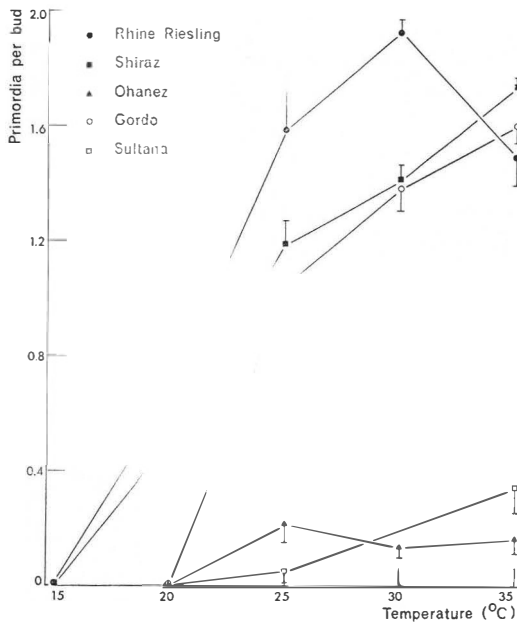


Fig. 1

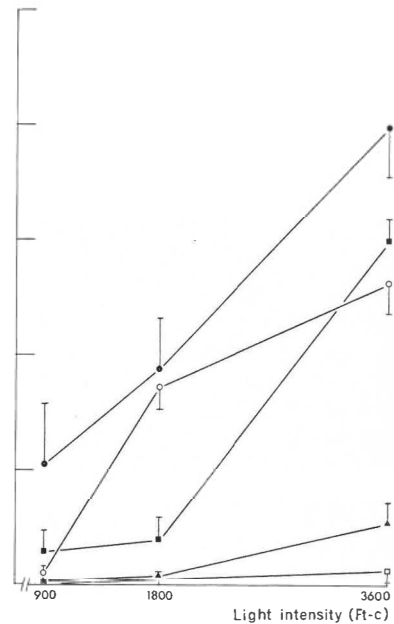


Fig. 2

Fig. 1: The effect of temperature on the mean number of bunch primordia per bud for the basal 12 buds on shoots. Light was 3600 f. c. for 16-hour days. The vertical bar at each point equals  $1 \times$  standard error of the mean.

Fig. 2: The effect of light intensity on the mean number of bunch primordia per bud for the basal 12 buds on shoots. Daylength was 16 hours at 25° C. The vertical bars equal  $1 \times$  standard error of the mean.

## Results

### a) Effects of temperature (at 3600 f. c.)

Results concerning primordia numbers, after 13 weeks in cabinets, are presented in Fig. 1. At 20° C Rhine Riesling and Shiraz had attained a fruitfulness of approximately 0.6 primordia per bud, whereas the other three varieties, including Gordo, were barren. Rhine Riesling was the most fruitful variety up to about 34° C, and reached peak fruitfulness at approximately 30° C. The data suggest that Gordo and Shiraz had not reached peak fruitfulness below 35° C. Both Ohanez and Sultana were very low in fruitfulness at all temperatures.

Results concerning size of bunch primordia of the three most-fruitful cultivars are presented in Table 1. There tended to be an increase in weight of primordia, as there was with their number, up to 30° C, at which temperature maximum sizes were recorded. Primordia tended to be smaller at 35° C than at 30° C, although only in the case of Rhine Riesling did the primordia number similarly fall. Primordium weight for Shiraz was affected relatively little by temperature, compared with Rhine Riesling and Gordo. At 30° C, primordia of Gordo were approximately twice as large as those of Shiraz or Rhine Riesling.

### b) Effects of light intensity (at 25° C)

Numbers of bunch primordia are shown in Fig. 2, and the results call for little comment. Fruitfulness, low at low light intensities, was promoted by an increase

Table 1

Mean fresh weight ( $\mu\text{g}$ ) of the most basal bunch primordium in bud 10, from shoots of the 3 fruitful cultivars when grown at 3600 f.c. and 16-hour-days, but with temperature differences

Temperature ( $^{\circ}\text{C}$ )	Rhine Riesling	Shiraz	Gordo
20 $^{\circ}$	8.3 $\pm$ 1.1	22.5 $\pm$ 7.6	0
25 $^{\circ}$	18.8 $\pm$ 3.2	16.3 $\pm$ 2.5	19.3 $\pm$ 2.9
30 $^{\circ}$	40.6 $\pm$ 7.0	30.0 $\pm$ 3.0	76.0 $\pm$ 8.2
35 $^{\circ}$	35.8 $\pm$ 7.5	25.6 $\pm$ 4.3	44.3 $\pm$ 9.6

in light intensity. Shiraz performed little better at 1800 f.c. than at 900 f.c., but responded vigorously to an increase above 1800 f.c. Rhine Riesling was the most fruitful cultivar at each intensity.

#### c) Effect of length of growing period on Sultana fruitfulness

Sultana plants maintained for 26 weeks, at 3600 f.c. for 16-hour days under a temperature regime of 25 $^{\circ}\text{C}$ /20 $^{\circ}\text{C}$ , were found to have  $1.42 \pm 0.10$  primordia per bud (buds 1—12), the fresh weight of the basal primordium in bud 10 being  $105.8 \pm 14.8 \mu\text{g}$ .

#### d) Effects of daylength

Table 2 shows primordia numbers from a limited investigation of daylength. Total light energy supplied by 8 hours at 3600 f.c. was equal to that given by 16 hours at 1800 f.c. The fruitfulness of Gordo was reduced to one third, and of Rhine Riesling to one half, by reducing daylength from 16 to 8 hours without changing total energy input. Shiraz was unaffected. A second comparison was made between the effect of 16 hours continuous light, on the one hand, and 16 hours composed of 12 hours continuous light and a 4-hour night break, on the other hand. Both for Rhine Riesling and Shiraz, fruitfulness was greater if light was supplied for a continuous period.

### Discussion

The relative unfruitfulness of Sultana and Ohanez, compared with the other three cultivars, constituted the most marked varietal difference observed. Whereas the fruitfulness of the other three cultivars, after 13 weeks in growth cabinets, could equal that of mature buds on field shoots, the fruitfulness of Sultana and Ohanez

Table 2

Mean number of bunch primordia per bud for buds 1—12 from shoots grown under different conditions of daylength at 25 $^{\circ}\text{C}$

	Rhine Riesling	Shiraz	Gordo	Ohanez
8 hours, 3600 f.c.	0.43 $\pm$ 0.12	0.10 $\pm$ 0.06	0.23 $\pm$ 0.09	0.01
16 hours, 1800 f.c.	0.75 $\pm$ 0.18	0.16 $\pm$ 0.08	0.69 $\pm$ 0.14	0.03 $\pm$ 0.02
16 hours, 3600 f.c.	1.59 $\pm$ 0.17	1.20 $\pm$ 0.08	1.05 $\pm$ 0.21	0.22 $\pm$ 0.07
12 hours, 3600 f.c. 4 hour night break <sup>1)</sup>	0.72 $\pm$ 0.18	0.78 $\pm$ 0.10	0.80 $\pm$ 0.10	0.0

<sup>1)</sup> 12 hours light, 4 hours dark, 4 hours light, 4 hours dark

was much lower. Because Sultana buds were very fruitful after 6 months, it is concluded that primordia had not developed sufficiently by 13 weeks for them to be recognized as bunch primordia on dissection. This is surprising because at 13 weeks Sultana buds, at basal nodes on the shoot, already had about 10 leaf primordia (unpublished data), and the basal bunch primordium is normally opposite the seventh leaf primordium. It is also surprising because MAY (6) found Sultana buds in the field to be fruitful by 13 weeks after bud-burst. Light intensity (3600 f. c.) in growth cabinets was only 25 per cent of that experienced in the field on bright sunny days, and it is conceivable that this factor is involved in delayed growth of bunch primordia.

Fruitfulness of buds of field-grown Sultanas is lower than that found in cabinet-grown plants after 26 weeks. BARNARD (1) investigated buds on irrigated vines in Southern Australia, and found that normally between 60 and 70% of shoots were fruitful, and of fruitful shoots only some 14% had two bunches. Field fruitfulness was therefore less than one half that of 26-week cabinet-grown buds. The fresh weight of bunch primordia in these buds (106  $\mu$ g in bud 10, 80  $\mu$ g in bud 5) was similar to, or slightly greater than, values reported by MAY (6, 7) for field grown Sultanas. He found little change in primordium fresh weight between 13 and 26 weeks. From these observations it is concluded that, under field conditions, bud development (bunch primordium differentiation) may be terminated at an earlier stage than occurs under an unchanging programme of conditions in cabinets.

Rhine Riesling, which is grown widely in cool areas, was indeed, of the cultivars examined, the most fruitful at low temperatures. However it was also the best performer, in respect of fruitfulness, at higher temperatures, a characteristic which also applies in respect of vegetative development (5). Shiraz was particularly tolerant to temperature in respect of fruitfulness, in that 50% of buds were fruitful at 20° C and yet peak fruitfulness was not reached below 35° C. Tolerance to a wide range of temperature in respect of vegetative growth was similarly an outstanding feature of Shiraz (5).

Considering the cultivars other than Sultana and Ohanez, Shiraz was outstanding in its dependence on high-intensity light for fruitfulness. Unless intensity was greater than 1800 f. c., buds remained barren. If high-intensity light was given for only 8 hours, however, buds still remained barren. Thus the amount of light energy received in any one day is important, and not the actual intensity of light. As occurred with low temperature, Rhine Riesling was the most fruitful cultivar at low light intensity, indicating that it would be at an advantage in cloudier areas. However, this advantage is maintained at higher intensities.

Gordo, in respect of fruitfulness, was relatively neutral to daylength (4), but Rhine Riesling and Shiraz performed best in long days. These results are similar to those concerning vegetative growth (5). On these grounds it is possible that, light intensity and temperature being equal, the performance of Rhine Riesling would improve with increase in latitude. However, at low latitudes, it is likely that any disadvantage to fruitfulness of Rhine Riesling resulting from somewhat shorter days would be offset by increased temperature and light intensity.

It is concluded that there is variation between *V. vinifera* cultivars in the way their fruitfulness responds to environment. Results suggest that all cultivars may perform well with high temperature and high light intensity, but fewer may be able to perform satisfactorily with low temperature and low light intensity.

### Summary

Plants of five cultivars (Sultana, syn. Thompson Seedless; Muscat Gordo Blanco; Rhine Riesling; Shiraz; and Ohanez) of grape-vine (*Vitis vinifera* L.) were grown for 13 weeks in controlled environment growth cabinets, and then the number of bunch primordia present in buds was counted after dissection. Sultana (S) and Ohanez (O) had very few bunch primordia under all conditions. Of the other cultivars all were barren after growth at 15° C, but Rhine Riesling (R) and Shiraz (Sh) had some primordia at 20° C, and Gordo (G) at 25° C. Primordia number of R, Sh and G increased with increase in temperature up to approximately 35° C. R had most at all temperatures. At a light intensity of 900 foot candles (f. c.) R had some primordia, but other cultivars were barren. At 1800 f. c. both R and G had a moderate number of primordia, but Sh was barren. At 3600 f. c. R, G and Sh all had fruitful buds. R had the greatest number of primordia at each intensity. R and Sh had more primordia when 16 hours of light per day were given continuously than when in two portions separated by 4-hour dark periods.

S and O produced very few bunch primordia under any of the conditions tested. Evidence is presented that this result was due to a later differentiation of bunch primordia in buds of these cultivars, such that primordia were still unrecognisable at 13 weeks. Of the other cultivars, R had more primordia at all temperatures and light intensities; each cultivar performed well at high temperature and light intensity, but only R performed well under poor conditions.

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Dr. M. S. BUTTROSE  
CSIRO  
Div. Horticult. Research  
Priv. Mail Bag No. 1  
Glen Osmond, S. Australia 5064  
Australia