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The Effect of Root Temperature on Development of Small Fruiting Sultana Vines

by

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Introduction

There is little information on the effects of temperature on fruiting plants and in particular on the effects of different shoot and root temperatures on vine development up to fruit-set.

Using controlled night temperatures Kobayashi et al. (1960) found that Delaware vines grew and set fruit best at night temperatures of 20° C but shoot growth in the first three weeks was best at 35° C. They used night temperatures ranging between 15° and 35° C but used uncontrolled day temperatures, the mean of which ranged between 18° and 27° C. With controlled day and night temperatures applied at the onset of flowering Alexander (1965) found that shoot growth of sultanas increased between night temperatures of 19° and 25° but he was unable to show differences in fruit-set between temperature regimes which ranged between 21° day — 19° C night and 30° day — 25° C night. In both these cases the vines had shoots and roots at common temperatures.

In the present experiment the roots of sultana vines were kept at a series of different temperatures while their shoots were growing at a common temperature. The effect of these treatments on shoot and root development of the sultana and the integrated effect of this development on fruit set was measured.

Methods

The experiment was conducted in a glasshouse during spring and early summer. Clonal sultana vines propagated by the aerial layering method described by Alexander and Woodham (1963) were removed from their source vines at budburst (September 11, 1964) and grown with their roots kept at 11 ± 1, 20 ± 1, or 30 ± 1° C by immersing three 30-litre drums of nutrient solution in water baths kept at these temperatures. Shoots of all treatments were at the ambient temperature of the glasshouse, which had heating to keep the temperature of the air above 20° C and cooling to keep it below 35° C, with vigorous air circulation. On October 8 the glasshouse was whitewashed to assist in temperature control.

Initially 15 vines each with three buds were grown in each treatment. After three weeks nine vines in each treatment with good inflorescence and shoot development were retained and the remainder discarded. These vines were pruned to one fruitful shoot. Three vines were grown in each drum. Hoagland's No. 2 nutrient solution was used and renewed frequently to avoid nutritional restraints.

Lengths of primary shoots and of inflorescences were measured at weekly intervals from September 21 to October 26, when lateral shoots started growing vigorously on some vines with roots at 30° C. During the flowering period (October 10 to 22) all flowers which abscissed from each inflorescence were collected and counted;

later the number of berries on each bunch was also counted and the percentage of flowers which developed into berries calculated.

The trial was terminated on November 5, 1964, two weeks after fruit set on the last vines to finish flowering. The oven-dried weights of laminae, petioles, stem, roots, and trunk and the fresh weight of fruit for each vine were recorded. The shoot/root ratio (excluding fruit and trunk) for each vine was estimated from the dry weights.

Results

The effect of root temperature on shoot and on inflorescence length during the period from budburst to one week after capfall is shown in Figures 1 A and 1 B respectively. Shoot growth increased with increasing root temperature and the differences between treatments increased with time (Figure 1 A). With roots at 11° C shoot growth stopped within three weeks of starting the treatments and the tips of three of these vines died after flowering. With roots at 20° C it practically stopped within five weeks and there was little growth of laterals. With roots at 30° C however the growth rate was still maintained after six weeks and in addition lateral shoots grew vigorously on some of the vines.

New root growth began within four days of starting the 30° and 20° C treatments but in the 11° C treatment no growth occurred for the first six weeks and very little thereafter. The roots at 30° C grew vigorously throughout with abundant new white growing points. The roots at 20° C practically stopped growing when the vines flowered and there were few elongating tips by the end of the experiment. The data

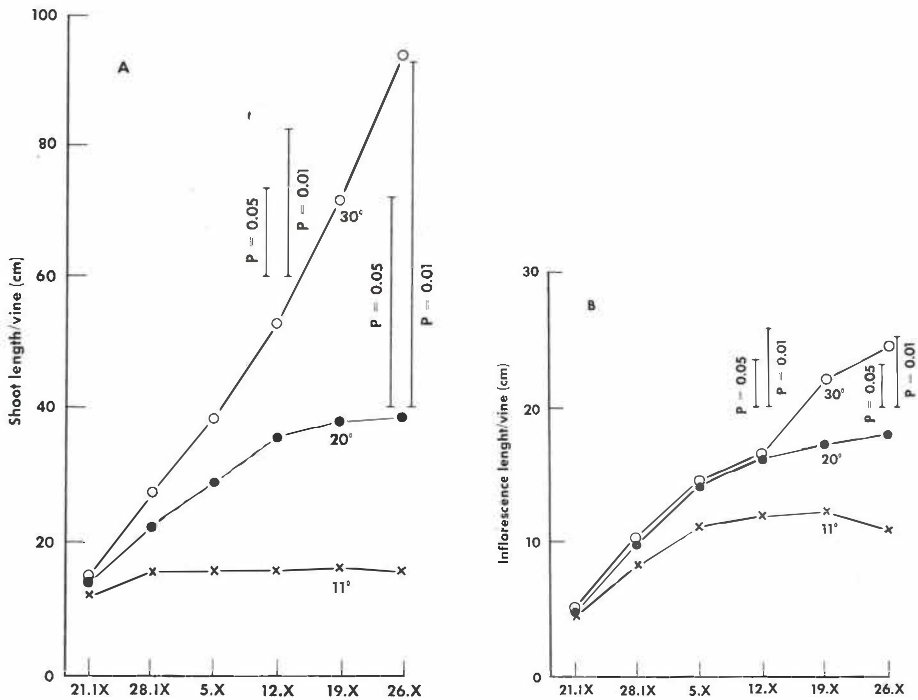

Fig. 1: Effect of root temperature (°C) on mean length of primary shoot per vine (A) and on mean inflorescence length per vine (B).

Table 1

Effect of root temperature imposed for eigth weeks frcm budburst on fruit set and plant development of sultanas.
Air temperatures were common to all treatments.

Root Tempe-rature (⁰C)	Fruit No Flowers per Inflo-rescence	% Set	Fresh Weight (g)	Shoot (g dry matter) Laminae	Petioles	Stems	Root (g dry matter)	Shoot/ Root Ratio
11	1299	2	1.8	1.6	0.17	0.67	3.0	0.96
20	1539	10	19.8	5.0	0.56	2.2	6.2	1.21
30	1768	23	74.2	19.4	2.90	13.4	8.5	4.13
L. S. D.								
P = 0.05	906	5*	39.8	10.3	1.78	9.9	3.1	2.24
P = 0.01	—	11*	65.9	17.1	2.96	16.3	5.1	3.74

Data are meants per vine.
* L. S. D. appropriate to 10 per cent set. The actual analysis used angular transformations.

on root and shoot growth indicate that shoot/root ratio rises steeply with increasing temperature (Table 1).

The increase in inflorescence length from budburst until the onset of flowering (October 10) was similar in the 30⁰ and 20⁰ C treatments. After flowering there was a further increase in inflorescence length in plants with roots at 30⁰ C (Figure 1 B). Inflorescence length tended to increase more slowly in the 11⁰ C treatment but did not differ significantly from the other treatments until October 12.

The start of flowering did not differ between treatments but capfall in the 11⁰ C treatment was retarded by about three days compared with the other two treatments. The mean numbers of flowers per inflorescence also did not differ significantly between treatments. However both per cent fruit-set and bunch weight increased with increasing root temperature (Table 1). As well the berries on vines with roots at 30⁰ C were larger than those on vines with roots at 20⁰ C (Plate 1). In the 11⁰ C treatment bunches either died or no berries set on five of the nine vines; on the other four vines several twigs abscissed at the bunch stem.

Discussion

In this experiment, in which root temperatures were closely controlled to three different values while air temperatures were controlled only between fairly wide limits and were common to all root treatments, shoot and inflorescence growth and fruit set as well as root growth increased markedly with increasing root temperature. The air temperatures were considerably higher, and higher for longer periods, than those under which sultanas grow in the field at the same stage of development. Best vine growth and fruit-set occurred with the root temperature at 30⁰ C, the nearest to the mean air temperature. Per cent fruit-set on these vines was comparable to that observed on fieldgrown vines and was much higher than that on vines with roots at 20⁰ C.

Thus although root temperature alone was varied in this experiment the results suggest that it may be the relationship between the temperature of shoots and of

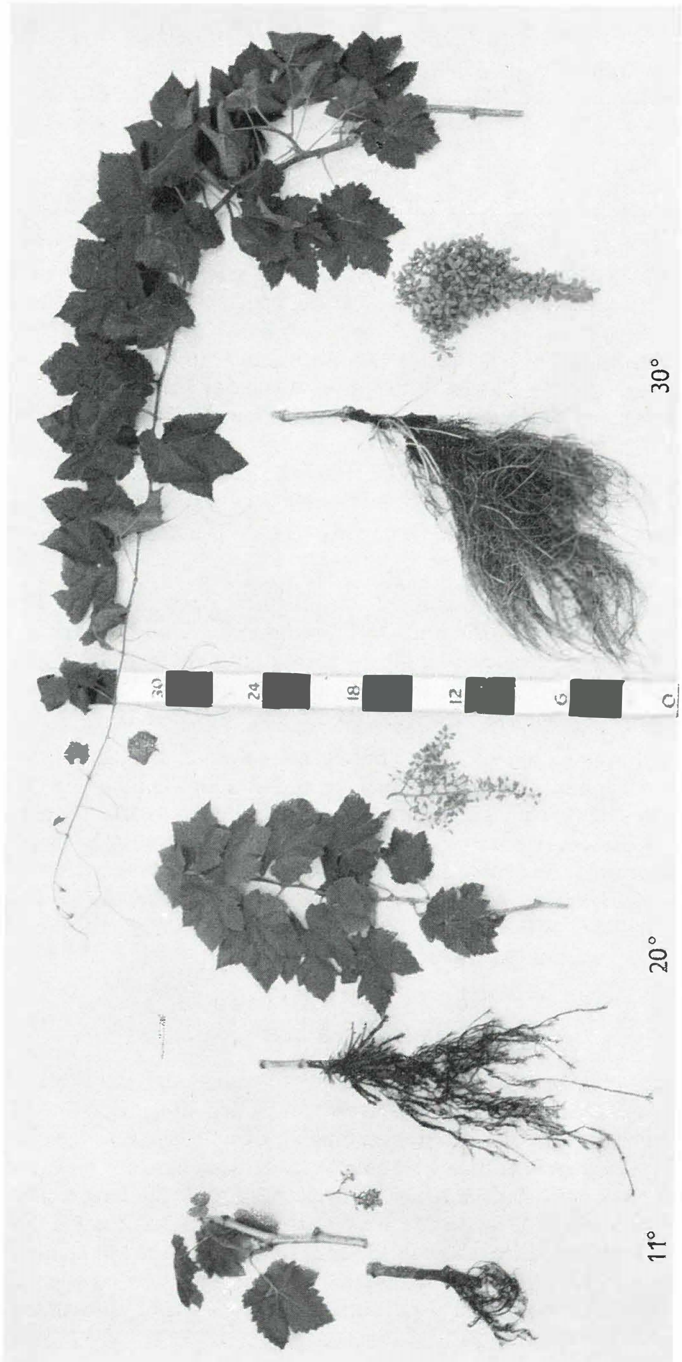

Plate 1: The effect of root temperature imposed for eigth weeks from budburst on shoot, root and inflorescence development of sultana vines.

roots that controls vine development. The poor growth of vines with roots at 11° C and the cessation of shoot and of root growth at about flowering of vines with roots at 20° C may have resulted from a temperature differential between shoots and roots which was too great for normal vine development.

Shoot growth of tomatoes and the shoot/root ratio increased with increasing root temperature in the range of 16.8° to 25.3° C when the shoot temperature was 25.3° C for all treatments (ABD EL RAHMAN, KUIPER, and BIERHUIZEN 1960). Similar results also with tomatoes were obtained by DAVIS and LINGLE (1961), who concluded that the reduced growth at low root temperature was not due to a restricted supply of minerals or of water to the shoot.

No symptoms of nutrient or water stress were observed in the present experiment. In view of the very pronounced kinin activity found in bleeding sap from the vine by NITSCH and NITSCH (1965) it seems more likely that a hormone imbalance between roots and shoots when these are at widely different temperatures may be responsible for the poor growth under such conditions.

Kinin activity has also been found in the root exudate of sunflowers by KENDE (1965) so that similar results for other plants would not be surprising.

Summary

Sultana vines were grown in solution culture for eight weeks from budburst with root temperatures kept at 11, 20, or 30° C. Air temperatures were common to all treatments and fluctuated between a minimum of 20° C at night and a maximum of 35° C in the day.

The growth of shoots, roots, and inflorescences increased with increasing root temperature. With roots at 30° C growth continued throughout the experiment; with roots at 20° growth practically stopped when the vines flowered, about four weeks after the experiment began; with roots at 11° C very little growth occurred.

The distribution of dry matter between the various plant parts differed between the different root temperatures; vines with roots at 30° C had the highest shoot/root ratio.

The percentage of flowers which set on plants with roots at 30° C was more than twice that on plants with roots at 20° C; with roots at 11° C either very few berries set or the bunches died.

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