TECHNICAL NOTE

Predicting the Date of Bud Burst in Grapevines

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It was possible to forecast the date of bud burst under South African winter temperatures (Region III) using the Pouget-formulae and principles, and to establish a scale of bud burst for cultivars grown in South Africa. The sum of daily temperature effects was higher under the warmer South African conditions which resulted in changes in the formulae for determining the daily effect of temperature and the cultivar coefficient on the bud burst date. Highly significant linear relationships were, however, obtained and it was possible to predict the date of bud burst fairly accurately.

Predicting the date of bud burst of grapevines has a number of practical advantages in that, *inter alia,* pruning can be planned more efficiently (e.g. the best time for pruning is 2-3 weeks before bud burst), while treatments against diseases (e.g. bud mite) and to homogenise and increase the percentage of bud burst (hydrogen cyanamide) can be timed more accurately.

From bud burst dates obtained over 25 years for 22 cultivars in France (Bordeaux, Region II according to Winkler *et al.,* 1974) as well as minimum and maximum temperatures during the period prior to bud burst, Pouget (1988) established a time scale for bud burst. Moreover, he indicated that it was possible to calculate the potential date of bud burst 2-3 weeks in advance. These calculations were based on "the law of the effect of temperature on rate of bud burst" (Pouget, 1967) and the sum of daily minimum and maximum temperature values from a fixed date during ecodormancy (post-dormancy).

The aim of this investigation was to determine the possibility of using Pouget's formulae and cultivar coefficients to predict the date of bud burst of cultivars grown in South Africa under conditions of higher winter temperatures. This would then also make it possible to determine similar cultivar coefficients for cultivars commonly grown in South Africa.

MATERIALS AND METHODS

Bud burst dates were recorded over 8 years on 15 *Vitis vinifera* L. cultivars grown on the VORI experimental farm, Stellenbosch (Region III). Dates used in this study were recorded when 50% of the buds allocated during pruning (spur pruned and long bearers) showed green colouring. The cultivars were grafted onto 99 Richter (cl RY 30) with a planting width of 3,0 x 1,5m, trellised on a 1,5m slanting trellis and pruned during August. Cultivars of which coefficients were determined by Pouget (1988), *viz.* Gewürztraminer, Chasselas blanc (Chasselas doré), Shiraz, Sauvignon blanc and Ugni blanc were used as reference cultivars.

Duration to bud burst: The duration to bud burst (D) was initially calculated as the number of days from 1 June, 15 June, 1 July and 15 July (during ecodormancy) up to and including the date of bud burst. These dates are sufficiently distant from bud burst for the buds of the various cultivars to be considered as being in a very similar physiological state regardless of date of bud burst.

Sum of daily temperature effects: According to Pouget (1988) temperature has a specific action on a cultivar which is proportional to the rate of bud burst (number of days required to 50% bud burst):

$$V_t = K.t^c \qquad (1)$$

where: V_t = rate of bud burst,
t = temperature,
c = cultivar bud burst coefficient,
K = cultivar coefficient.

This temperature effect, which differs according to cultivar, is calculated from the effect of daily maximum and minimum temperatures and can be expressed as follows (Pouget, 1988):

$$a_j = \frac{K.t_M^c + K.t_m^c}{2} \qquad (2)$$

where: a_j = temperature effect for day j with j representing each day from 1 July up to and including date of bud burst.
t_M = maximum temperature on day j,
t_m = minimum temperature on day j,

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c = cultivar bud burst coefficient,

K = cultivar coefficient.

The daily temperature effects (aj) are cumulative and their sum (S) is calculated each year from the starting date (1 July) up to and including the actual date of bud burst i.e.:

$$S = \Sigma a_j \tag{3}$$

Calculation of cultivar coefficients and critical bud burst temperatures: Pouget (1969) indicated a significant relationship between the cultivar coefficient K and the cultivar bud burst coefficient c, *viz.* log **K** = 2,57403 - 1,72494**c**. Futhermore, a critical temperature is also required for bud burst (growth-threshold temperature, $\mathbf{t_d}$), which can be calculated by the formula $\mathbf{t_d}$ = 9,31**c** - 6,40 (Pouget, 1988).

RESULTS AND DISCUSSION

Relationship between S, D and c: For the 5 reference cultivars in this study a highly significant negative linear relationship (r=-0,9708) was obtained between S and D (Fig. 1), where D was the number of days from 1 July to bud burst. This can be described by the following formula:

$$\mathbf{S} = 11\,841 - 112{,}3225\mathbf{D}\ (r^2=0{,}9425) \tag{4}$$

From this formula and the mean duration to bud burst (D) that was measured over a period of 8 years it was thus possible to calculate S for the other cultivars (Table 1).

From a plot of the cultivar bud burst coefficient (c) of Pouget (1988), calculated for Stellenbosch against S for the reference cultivars (Fig. 2), it was evident that a highly significant negative linear correlation (r=-0,9973) existed, which was characterised by the formula:

$$\mathbf{c} = 2{,}802886 - 0{,}0003545\mathbf{S}\ (r^2=0{,}9947) \tag{5}$$

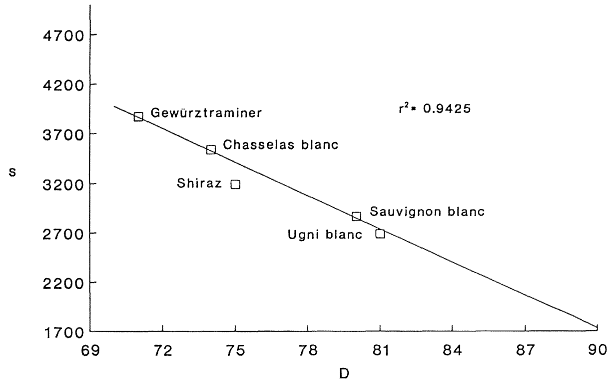

FIGURE 1
The relationship between the average sum of daily temperature effects (S) and the average duration up to and including bud burst (D) at Stellenbosch for five reference wine grape cultivars.

It was thus also possible to determine c for the other cultivars used in this study and from these c-values, K and $\mathbf{t_d}$ could also be calculated for these cultivars using the formulae given by Pouget (1969, 1988) (Table 1).

From Table 2 it is evident that D-values obtained for the reference cultivars under South African conditions were slightly lower, especially for the later maturing cultivars compared to those found in France. This can be ascribed to higher temperatures during the period when bud burst occurred. For the same reason S-values were also higher than those calculated by Pouget.

TABLE 1
Parameters for predicting time of bud burst for 15 wine grape cultivars.

Cultivar	Average date of bud burst over 8 years	Average duration to bud burst, D (days)	Calculated values of S	Calculated values of c	Calculated values of K	Bud burst temperature, t_d (°C)
Limberger	3 Sept.	64,7 ± 5,4	4574	1,184	3,402	4,6
*Gewürztraminer	10 Sept.	71,8 ± 6,5	*3872	*1,442	*1,221	*7,0
Portugais bleu	10 Sept.	71,8 ± 4,7	3776	1,466	1,110	7,2
Chenin blanc	11 Sept.	72,9 ± 5,6	3653	1,510	0,932	7,7
Grenache	12 Sept.	73,4 ± 4,9	3597	1,530	0,861	7,8
Carignan	13 Sept.	73,8 ± 4,9	3552	1,545	0,811	*8,0
*Chasselas blanc	13 Sept.	74,3 ± 4,8	*3539	*1,542	*0,821	8,0
Weisser Riesling	13 Sept.	74,3 ± 6,3	3495	1,566	0,746	8,2
*Shiraz	14 Sept.	75,2 ± 5,4	*3193	*1,658	*0,518	*9,0
Pinotage	15 Sept.	75,7 ± 5,7	3338	1,621	0,600	8,7
Muscat d'Alexandrie	18 Sept.	80,0± 5,5	2855	1,792	0,304	10,3
*Sauvignon blanc	18 Sept.	80,1 ± 6,5	*2870	*1,779	*0,320	*10,2
Cabernet Sauvignon	19 Sept.	80,6 ± 9,9	2789	1,816	0,276	10,5
Kadarka	19 Sept.	80,7 ± 4,9	2687	1,852	0,240	10,8
*Ugni blanc	20 Sept.	81,8 ± 7,8	*2689	*1,865	*0,223	*11,0

* Reference cultivars, S, K c and $\mathbf{t_d}$ obtained from Pouget (1988).
D Calculated from 1 July.
S Sum of daily temperature effects.
c Cultivar bud burst coefficient.
K Cultivar coefficient.

TABLE 2
A comparison of duration to bud burst (D) and a summation of daily temperature effects (S) for five reference wine grape cultivars at Stellenbosch and Bordeaux.

Cultivar	**D (days)**		**S**	
	Stellenbosch*	**Bordeaux****	**Stellenbosch**	**Bordeaux**
Gewürztraminer	71,85	72,12	3871,9	1585,0
Chasselas blanc	74,29	74,39	3539,0	1475,0
Shiraz	75,17	78,78	3193,3	1342,0
Sauvignon blanc	80,14	83,33	2869,7	1203,0
Ugni blanc	81,83	85,94	2689,2	1089,0

* Calculated from 1 July.
** Calculated from 1 January.

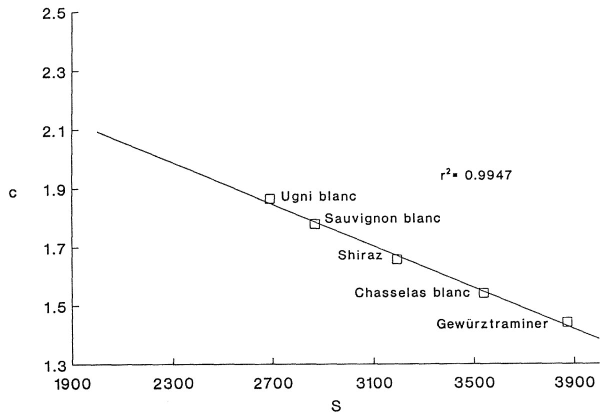

FIGURE 2
The relationship between cultivar bud burst coefficient (c) of Pouget (1988) and the average sum of daily temperature effects (S) at Stellenbosch for five reference wine grape cultivars.

TABLE 3
A comparison between observed and predicted bud burst dates for different wine grape cultivars at Stellenbosch (1989).

Cultivar	**Observed date**	**Predicted**
Limberger	2 Sept.	2 Sept.
*Gewürztraminer	15 Sept.	13 Sept.
Portugais bleu	15 Sept.	13 Sept.
Chenin blanc	14 Sept.	14 Sept.
Grenache	20 Sept.	15 Sept.
Carignan	15 Sept.	15 Sept.
*Chasselas blanc	19 Sept.	16 Sept.
Weisser Riesling	16 Sept.	18 Sept.
*Shiraz	23 Sept.	18 Sept.
Pinotage	20 Sept.	18 Sept.
Muscat d'Alexandrie	25 Sept.	23 Sept.
*Sauvignon blanc	27 Sept.	23 Sept.
Cabernet Sauvignon	29 Sept.	25 Sept.
Kadarka	30 Sept.	27 Sept.
*Ugni blanc	2 Oct.	28 Sept.

* Reference cultivars

Prediction of date of bud burst: Pouget (1988) also found, that in a specific year, bud burst occurred when the daily temperature effects for that specific year (s), also calculated according to formulae 1 and 2, reached a value close tot the long-term constant S of that cultivar. From the c and K-values in Table 1 it was also possible to calculate, by employing formula 1, the rate of bud burst (V_t) at a specific temperature for a cultivar.

These V_t-values could then be used to calculate the value of a_j for each day in a specific year and to express the sum of daily temperature effects for a specific year (s) as a percentage of the average sum of daily temperature effects for that cultivar (S). These s/S x 100-values are an indication of the physiological state of buds and are graphically depicted in Fig. 3 for 1988 from the starting date up to bud burst.

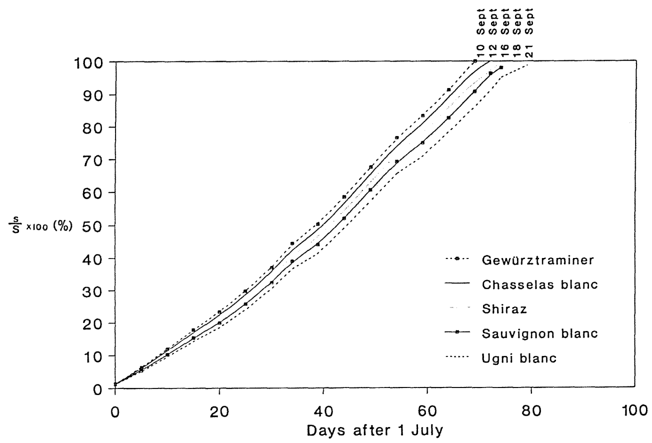

FIGURE 3
The change of s/S x 100 during 1988 for five reference wine grape cultivars (s is sum of daily temperature effects for 1988 and S is long-term average sum of daily temperature effects).

When s reaches a value of 80% of that of S, bud burst is expected to occur within 2-3 weeks, depending on the cultivar and on temperatures during that time. This method can, therefore, be used to determine the date of bud burst more accurately than was previously possible. If treatments are to be applied at certain periods before bud burst (e.g. hydrogen cyanamide application), that period (days) can be substituted by a percentage of S.

The prediction of the dates of bud burst was done at the end of August 1989 according to the abovementioned procedure and it was possible to predict fairly accurately the date of bud burst (Table 3). The actual bud burst dates which occurred later than predicted can be ascribed to low average temperatures during the first half of September 1989 (data not shown). Furthermore, the somewhat larger differences for certain cultivars can be ascribed to the fact that the growth threshold temperatures (t_d) were not reached for those cultivars.

CONCLUSIONS

A comparison of local observations with that of Pouget (1988) in Bordeaux showed that, with the aid of his formulae, it is possible to establish a time scale for bud burst and to predict the bud burst dates of cultivars grown in warmer climates such as that of Stellenbosch. Due to local higher winter temperatures, the sum of daily temperature effects (S) is higher than those obtained under cooler winter temperatures, and therefore the formulae for the calculation of S and c (cultivar bud burst coefficient) differ from that of Pouget (1988). However, good linear relationships between S duration to bud burst (D) and c were obtained for Stellenbosch.

Differences in observed dates of bud burst between cultivars can sometimes be smaller than differences between clones. Factors such as clone, rootstock, vigour, trellising system and time of pruning are, therefore, also important in the determination of the time of bud burst of a cultivar.

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