Adoption of a system for identifying grapevine growth stages

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Keywords: *Grapevine, growth stages, phenology*

Abstract

The foregoing paper by Lorenz et al. (1995), translated into English by P. May, describes a new system for the identification of grapevine growth stages called the BBCH system. This is an adaptation, for the grapevine, of a basic scale developed to cover all monocot and dicot crops. Appraisal of this and two other systems has led to a preference for that by Eichhorn and Lorenz (1977) but with some amendments. These amendments are discussed and a new system of measurement and description of stages of the grapevine is proposed which copes with the dual needs for a simple listing of major stages and, at the same time, provides intermediate detailed stages. It is called the Modified E-L system.

Introduction

The identification of growth stages for the grapevine, as with all crop plants, is necessary for the communication of cultural information, for decisions on establishment and cultural operations, and for use by research workers in the conduct of grapevine experiments. It is desirable that an adopted system be precise and be widely known and widely used.

To date, three descriptive systems have been developed for grapevines: (a) Baggiolini (1952), (b) Eichhorn and Lorenz (1977) and (c) the BBCH system which was developed as a model for the European Union and adapted for the grapevine by Lorenz et al. (1994). The first two have been described by Coombe (1988) and a detailed description of the third is given in the preceding paper of this journal. A useful photographic series was published by Wolpert (1992) but its utility is limited by an emphasis on shoot length and the lack of convenient identifiers for each growth stage.

The purpose of the present paper is to appraise and compare the three systems and to make recommendations for the adoption of a system that is judged to suit Australian viticulture and which serves for identifying grapevine development for all usages, cultural and research, and not just for pesticide use. The details have been widely canvassed amongst colleagues (and hence the authorship is regarded as plural).

Comparison of the three systems

The Baggiolini system was the first proposed and, because of its clear sketches and simple descriptions of ten stages between 'budburst' and 'setting', was widely adopted as an aid to the timing of pesticide sprays. However one of its drawbacks was the lack of description of growth stages after setting; this defect was removed by the addition of six more stages in a recent comprehensive amendment by Baillod and Baggiolini (1993). These are similar to the extra stages suggested by Peterson which are described in Coombe (1988). The new Baggiolini stages, labelled from A to P, have no provision for intermediate stages and this is considered a defect for precise and comprehensive identification of grapevine development.

The Eichhorn and Lorenz (1977) system addressed these defects with a more comprehensive scheme; it covers 22 stages from 'winter bud' to 'end of leaf fall'. A spread of 47 numbers was used with gaps to permit insertion of further intermediate stages. The silhouette drawings and the accompanying word descriptions were effective and, in fact, have been retained in similar form for the BBCH scheme (see Figure 1 and Table 1 in the preceding paper). The Eichhorn and Lorenz system has been adopted by many authors.

The BBCH system derived from a proposal, within the European Union, to adopt a uniform code—called the Extended BBCH Scale—that covered all monocot and dicot crops. It results from the activity of the BBCH working group and is described by Hack et al. (1992). Ten macro-stages (or principal growth stages) are listed covering all development from germination/budburst to senescence/dormancy. Within each macro-stage there are up to ten micro-stages (or secondary growth stages) giving a comprehensive system with numbers from 00 to 99. The code has now been adapted to the following crops: cereals, rice, maize; oilseed rape, Faba bean, sunflower; Beta roots; potato; vegetable crops; fruits (pome, stone, currants and strawberries); and the grapevine (see Lorenz et al. – preceding paper). A valuable compendium covering all of these codes has been compiled by Stauss (1994).

In the adaptation of the BBCH code to the grapevine, seven macro-stages were included: 0 - bud development, 1 - leaf development, 5 - inflorescence development, 6 - flowering, 7 - fruit development, 8 - fruit ripening, and 9 - senescence; three were omitted, namely, 2 - tillering, 3 - shoot development, and 4 - development of harvestable vegetative parts. The adaptation was built upon the Eichhorn and Lorenz system and some overlap has resulted – e.g. the Eichhorn and Lorenz stage 15 is equal to BBCH stage 53, and stage 19 equals 55. The BBCH system tends to fragment and zigzag development rather than provide a continuous flow from the beginning to the end of the season as occurs in the original system. Some minor errors have been noted, for example, the use of 'shoot tips' rather than 'leaf tips' and placing 'berry softening' after 'berry colouring'. Some terminology is poorly understood locally such as 'flower-hood', 'berries groat-size', 'berry touch', and 'brighting of berry colour'; instead we suggest: 'flower cap', 'berries pepper-corn size', 'berry touch (when bunches are tight)' and 'change in berry colour'. Another problem is that some characters are too variable for use in a univeral system, e.g. the timing of leaf discoloration varies considerably due to influences of water and nitrogen status; also 'berry touch' varies according to the degree of bunch tightness which, in turn, varies between cultivars and degree of fruit-set. The main virtues of the BBCH scheme are that it is uniform across different crops and that it may become the adopted system for European grape-growing countries and pesticide manufacturers.

Requirements of a descriptive system

To be a successful system of growth stage identification, such a system should: (a) contain a succession of developmental events that always follow each other, (b) have stages that are easily described, and be clearly recognised and identified, and (c) have stages selected for consistency in assessment. The latter is one of the main problems in the application of a system and, where possible, guides to the problems of variability within and between vines should be provided. An important aid for this problem is to have a numerous sequence of stages since identification of successive events improves the precision of identification of each of them.

The words used for description of each stage need to be unambiguous and widely understood. Because of the subjectivity and possible inaccuracy of assessment of qualitative terms, we favour specification by measured values, where appropriate, to increase the precision of records. We understand that, in the BBCH system, the use of measured values is avoided because of variability problems. However we have found that this problem is minimal during the early development of grapevine organs, e.g. of young shoots and berries, and that such a specification is helpful.

Data for assessing a system

To provide measurements for testing the performance of a descriptive system on different grape cultivars, two shoots, one short and the other long, were marked on single vines of cvs Flame Seedless, Sultana, Cabernet Franc and Muscat Gordo Blanco growing at Mitcham, near Adelaide; abbreviations of Flame, Cabernet and Muscat are used. Beginning on 21 October 1989, each shoot was measured weekly until 3 March, an interval of 19 weeks or 133 days. Records were kept of shoot length, the number of visible internodes (those longer than 7 mm), the lengths of the rachis and pedicel, an estimate of the percentage of flower caps fallen, diameter of three marked berries and concentration of total soluble solids (TSS) of juice from three berries picked from adjacent bunches. The basal bunch was used for rachis length measurement, starting from the first branch and excluding the wing.

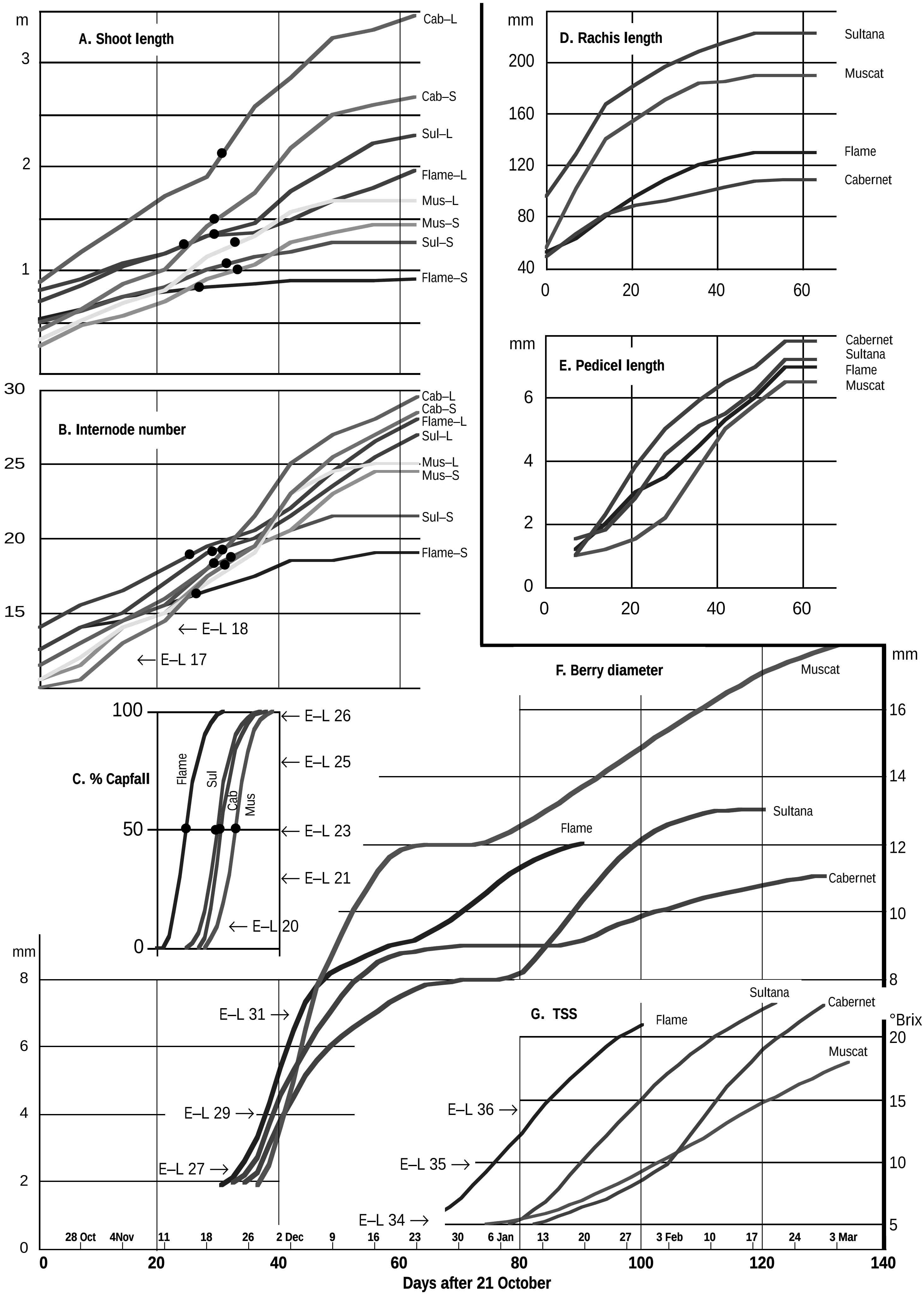
Most of the measurements are graphed against date of occurrence in Figure 1. Those relating to dimensions of reproductive organs—inflorescences, bunches, pedicels, berries and juice TSS—are the average of values from the two shoots since their values were similar. The date of 50% capfall is marked '●' on all curves showing shoot lengths and internode numbers. The following points from each set are pertinent:

A. Shoot lengths varied widely showing a difference of 3.4-fold on October 21 (day 0) and 3.8-fold on day 60. The percentage lengthening during 60 days varied from 174% (Flame-short) to 390% (Cabernet-long). There were large differences in shoot length at flowering. The end of shoot lengthening, when tips abscise, occurred by day 56 in four of the eight shoots but well after measurements stopped in the others. Clearly, this characteristic is unsuitable for the identification of developmental stages (with the exception of the '10 cm stage').

B. The curves of numbers of internodes were somewhat parallel until day 35 whereupon they diverged. The number of internodes varied by ± 2.5 on October 21, by ± 1.6 on November 21 and by ± 6.0 on December 21. The date of 50% capfall, marked '●', occurred at 19 internodes for seven of the eight shoots (but at 16 on Flame-short). In a later test, the measure 'number of visible internodes' was compared with the 'number of unfolded leaves', i.e. all leaves including that at the shoot tip which is spaced away from the tip and on which the petiole and its neighbouring internode are >5 mm in length. It was found that the values for 'leaves separated' were only 1.6% greater than 'number of internodes' and therefore either can be used. Most commentators favour the phrase 'leaves separated'.

C. The curves of % flower capfall were smoothed from percentage values estimated from twice-weekly inspections. Flowering occurred rapidly, being completed in ten days in all bunches. Sultana, Cabernet and Muscat reached 50% capfall 5, 6 and 8 days later than this stage in Flame which was the earliest.

D. Rachises lengthened considerably during the month before flowering, especially those of Sultana and Muscat, then added a small increment (about 11%) during the next month (also shown by Theiler and Coombe 1985). Strangely, rachises stopped elongating on all shoots on the same date (December 9).


A. Shoot length
m
Cab–L
Cab–S
Sul–L
Flame–L
Mus–L
Mus–S
Sul–S
Flame–S
B. Internode number
Cab–L
Cab–S
Flame–L
Sul–L
Mus–L
Mus–S
Sul–S
Flame–S
← E–L 18
← E–L 17
C. % Capfall
Flame
Sul
Cab
Mus
← E–L 26
← E–L 25
← E–L 23
← E–L 21
← E–L 20
D. Rachis length
mm
Sultana
Muscat
Flame
Cabernet
E. Pedicel length
mm
Cabernet
Sultana
Flame
Muscat
F. Berry diameter
mm
Muscat
Flame
Sultana
Cabernet
E–L 31 →
E–L 29 →
E–L 27 →
G. TSS
°Brix
Flame
Sultana
Cabernet
Muscat
E–L 36 →
E–L 35 →
E–L 34 →
28 Oct
4Nov
11
18
26
2 Dec
9
16
23
30
6 Jan
13
20
27
3 Feb
10
17
24
3 Mar
Days after 21 October

E. Pedicels accelerated lengthening just before flowering, by then being from 55 to 62% of their final length. They continued growth for another four weeks and, like rachises, stopped lengthening on the same date, but one week later (on 16 December). The coincident dates of length stoppage of rachises and also of pedicels, despite varying dates of full-bloom and cessation of shoot lengthening, suggests that these characteristics are not useful for a descriptive system. In any case they are tedious to measure.

F. Berry diameters passed the stage of 2 mm during the last week of November, Sultana, Cabernet and Muscat being coincident while Flame was four days ahead. The 4 mm diameter stage showed similar spacing except that Cabernet was one day later. The 7 mm diameter stage showed a wider separation, covering two weeks, in the order Flame > Muscat > Cabernet > Sultana. This stage occurred before the beginning of the slow-growth phase of the berries. From the stage of '7 mm berry diameter' until the inception of berry expansion of the ripening phase there were no measurements that offered distinguishing characteristics. This presents difficulties for the definition of stages 32 and 33.

G. Juice TSS started from the lag-phase level of about 5°Brix, then increased coincidently with the second increase in berry diameter. All cultivars showed regular increases in TSS with Flame earliest, then Sultana, Muscat and Cabernet. Rate of increase was similar in all except Muscat which was considerably slower.

Although these measurements are unreplicated and are only indicative, they do support the choice of characteristics that have been used to describe the progress of grapevine growth, namely, numbers of leaves, inflorescence development and flowering, berry development and ripening, and senescence. They show the value of the trait 'number of leaves separated' for describing the development until full-bloom of shoots of most pruned *Vitis vinifera* vines. However the pattern described does not hold for minimally pruned vines (Clingeleffer 1984) nor for *Vitis labruscana* cultivars (Pratt and Coombe 1978) where numbers of leaves are smaller at full-bloom: for these circumstances the choice of stages between E-L 12 and E-L 19 should be guided by the state of the inflorescences.

Figure 1. (Opposite page) Curves of measurements made on shoots of four grape varieties at weekly intervals during one season. Curves of shoot length and number of visible internodes (A and B) are of eight shoots, four short and four long, of four varieties, those of per cent capfall (C) are from bunches on long shoots, and the others (D rachis length, E pedicel length, F berry diameter, G juice TSS as °Brix) are the average of measurements on short and long shoots. The date of 50% capfall is marked '●' on all curves of A, B and C. Some positions of selected E-L stages are indicated in graphs B, C, F and G.

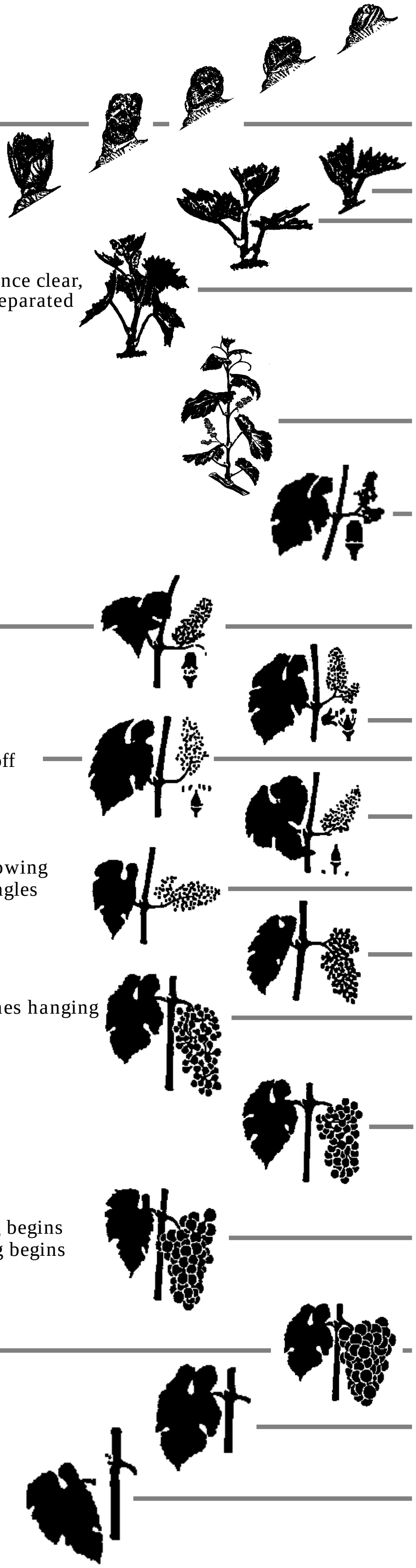
Table 1. Comparison of the lettering or numbering used to identify growth stages of the grapevine in four schemes.

	Baillod & Baggiolini	Eichhorn & Lorenz	Modified E-L	Extended BBCH
	A	01	1	00
		02	2	01
	B			03
		03	3	05
Budburst	C	05	**4**	07
	D		5	09
	E	07	7	11
		09	9	12
				13
			11	14
Shoots 10 cm	F	12	**12**	15, 53
			13	16
			14	
	G	15	15	19 55
			16	
	H	17	17	57
			18	
Flowering begins		19	**19**	60
			20	61
		21	21	63
Full bloom	I	23	**23**	65
		25	25	68
		26	26	69
Setting	J	27	**27**	71
		29	29	73
	K	31	31	75
		33	32	77
	L		33	79
			34	
Veraison	M	35	**35**	81
			36	
			37	
Harvest	N	38	**38**	89
			39	
	O	41	41	91
				92
	P	43	43	93
				95
		47	47	97

Discussion

Users of growth stage schemes may want descriptions of a limited number of major stages or, alternatively, a detailed set of precisely defined stages. It was decided to combine both needs in the one scheme. As stated above a scheme of growth stages will be most useful if its sequence of these stages is continuous, the stages are clearly identifiable, have wide applicability and low variability. The Eichhorn and Lorenz (1977) system was judged to provide the best basis of such a scheme for grapevines and has led to the development of a modified set of growth stages (see chart). The phrase Modified E-L is used for this chart and each stage is

Grapevine growth stages – The modified E-L system



MAJOR STAGES

E-L number		
4	**Budburst**	
12	**Shoots 10 cm**	Inflorescence clear, 5 leaves separated
19	**Flowering begins**	
23	**Full bloom**	50% caps off
27	**Setting**	Young berries growing Bunch at right angles to stem
31	**Berries pea size**	Bunches hanging down
35	**Veraison**	Berry softening begins Berry colouring begins
38	**Harvest**	Berries ripe

ALL STAGES

E-L number		
1	Winter bud	Shoot and inflorescence development
2	Budswell	
3	Woolly bud—brown wool visible	
4	Green tip; first leaf tissue visible	
5	Rosette of leaf tips visible	
7	First leaf separated from shoot tip	
9	2 to 3 leaves separated; shoots 2-4 cm long	
11	4 leaves separated	
12	5 leaves separated; shoots about 10 cm long; inflorescence clear	
13	6 leaves separated	
14	7 leaves separated	
15	8 leaves separated, shoot elongating rapidly; single flowers in compact groups	
16	10 leaves separated	
17	12 leaves separated; inflorescence well developed, single flowers separated	
18	14 leaves separated; flower caps still in place, but cap colour fading from green	
19	About 16 leaves separated; beginning of flowering (first flower caps loosening)	Flowering
20	10% caps off	
21	30% caps off	
23	17-20 leaves separated; 50% caps off (= full-bloom)	
25	80% caps off	
26	cap-fall complete	
27	Setting; young berries enlarging (>2 mm diam.), bunch at right angles to stem	Berry development
29	Berries pepper-corn size (4 mm diam.); bunches tending downwards	
31	Berries pea-size (7 mm diam.)	
32	Beginning of bunch closure, berries touching (if bunches are tight)	
33	Berries still hard and green	
34	Berries begin to soften; Brix starts increasing	Ripening
35	Berries begin to colour and enlarge	
36	Berrries with intermediate Brix values	
37	Berries not quite ripe	
38	Berries harvest-ripe	
39	Berries over-ripe	
41	After harvest; cane maturation complete	Senescence
43	Beginning of leaf fall	
47	End of leaf fall	

Modified from Eichhorn and Lorenz 1977 by B.G. Coombe

Chart. (Opposite page) Modified E-L system for grapevine growth stages.

identified as E-L to distinguish from that used for the original, labelled EL—see previous paper. Many of the E-L stages are superimposed on to the graphs shown in Figure 1.

The modifications from the original EL scheme are listed below in successive segments including comments on the Baggiolini and BBCH schemes. Table 1 provides a comparison of the relative identification lettering/numbering for all four schemes.

- Budburst: E-L stages 2 to 5 cover progressive stages in the bursting of buds. There are small variations from the identifiers in the other three schemes. E-L 4 (green tip) has here been chosen as the major stage called 'budburst'. Note that all subsequent numbers of major stages are the same numbers as those used by Eichhorn and Lorenz.

- Shoot development: Both BBCH and Eichhorn and Lorenz used number of leaves separated (or unfolded or displayed) as criteria, the former scheme to leaf nine, the latter to leaf six. The present results and the information in Pratt and Coombe (1978) have prompted the continuation of these numbers up to 17-20 leaves at full-bloom. The use of the stage 'shoots 10 cm long' (E-L 12) is a new term included because of its importance for the timing of some disease sprays; it approximates the 5-leaf stage (which, in fact, include most of the leaves that were present as primordia in the winter bud).

- Inflorescence development: Unlike the BBCH scheme, the stages of inflorescence development have been used in all other schemes in conjunction with shoot development. The stages are: inflorescences clear (E-L 12), flowers grouped (E-L 15), flowers separated (E-L 17). However an additional stage has been added—cap colour fading from green (E-L 18).

- Flowering: There are small differences between schemes in the identifying numbers used for these stages but all depend on the same criteria of per cent cap-fall (10, 30, 50 and 80).

- Berry development: The problem of the terms used for specifying berry size has been discussed above; for reasons described there berry diameters have been included, namely, >2, 4 and 7 mm for E-L stages 27, 29 and 31 respectively. For stage 32 we have added a cautionary note that 'berry touching' may not occur if bunches are loose. Stage 33 is difficult because no single characteristic serves to identify it; the words 'berries still hard and green' are to show this fact. The start of berry softening and sugaring denotes that stage 34 has arrived; close observation or measurement are needed to detect these.

- Berry ripening: While E-L 34 could be said to indicate veraison, the original definition refers to 'berry colour change' and this definition has been used (E-L 35). The increase in concentration of TSS is a reliable indicator for the progress of berry ripening. Specification of actual levels, as °Brix, °Baumé or °Oechsle, is possible for particular vineyards and usages; e.g. for E-L stages 34 to 39, values of TSS that might be chosen could be 7, 10, 14, 18, 22 and 27°Brix (i.e. 4, 6, 8, 10, 12 and 15°Baumé or 25, 40, 60, 75, 95 and 120°Oechsle. However only words are used here as identifiers.

- Senescence: The E-L stages specified are the same as those used for the other schemes.

Recommendation: Aids to users of the guide

The new code, called the Modified E-L system for grapevine growth stages, is illustrated in the chart.

As mentioned above, the recording of detailed stages improves the precision of all records and also helps cope with the timing vagaries of recording which is made difficult by developmental differences between years, sites, varieties, vineyards and blocks. Even within the one block, variable development between vines and shoots may cause confusion. As a help to reduce divergent assessments between recorders, the following protocol is suggested:

- (a) Identify and delineate reasonably uniform blocks of vines; for example, a change in soil type along a row may indicate a division for separate recording.
- (b) Select and mark a handful of scattered representative vines.
- (c) On each of these vines select and mark one shoot that typifies the majority of the shoots on that vine. Ignore the most vigorous and the weaker shoots. This selection is easier at E-L stage 12 when the inflorescence is clearly visible. Switch to another shoot if the selected shoot develops atypically.
- (d) Assess each shoot by comparison with the chart and record the result.

Careful assessment of a limited number of selected shoots gives more useful records than casual scanning of a block. Numbers of vines and shoots will be indicated by experience after several years of recording.

The BBCH system is being advocated for use in European countries and may be adopted by pesticide manufacturing companies for use on product labels. The possibility that both the E-L and BBCH systems will be used in future makes necessary a means of conversion from one to the other. Table 1 serves this purpose.

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Manuscript received: 1 September 1995