

Phenological responses of grapevine scions to rootstocks

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Abstract

The introduction into Australia of rootstocks was initially to overcome phylloxera infestations in the late 19th century. Restricted spread of phylloxera across the country has consequently limited the immediate requirement for rootstocks in Australia. Recognition of the benefits of rootstocks has since expanded to include nematode control, salinity tolerance and increased water use efficiency. This has further led to research on scion responses to rootstocks, particularly in relation to yield, fruit composition, comparative pest resistance, salinity, nutrition and water relations. Despite the commonly-held view that rootstocks influence the scion, when examining the relationship between rootstock and scion specifically with regard to phenology, there is little rigorous evidence to support this view. The influence of rootstocks on the phenological characteristics of grafted scions is the subject of this review.

1. Introduction

The importance of rootstocks in viticulture is well documented, particularly in relation to phylloxera and nematode control or in regards to nutrient exclusion, uptake of water in the vine (McCarthy et al. 1997, Keller 2001, Walker et al. 2000).

The phenological calendar is an important tool for viticulturalists as it aids in defining the viticultural season and provides insight into the potential of the crop and harvest period. The timing of each phenological stage is influenced by the variety, climate and geographic location (Jones and Davis 2000) and is affected by localised environments including soil, nutrient availability and presence of pests and diseases.

Based upon previous information from researchers on the direct effects of grafting rootstocks to scions (McCarthy et al. 1997, Keller 2001, Walker et al. 2000), it is thus postulated that rootstocks will impact on the timing of certain phenological stages. This relationship is further explored as the known effects of rootstocks on the scion are discussed with particular attention to the associated rootstock effects on growth and how this might influence scion phenology.

2. Grapevine Phenology

The annual growth cycle of a grapevine has been characterised by various authors (Lorenz et al. 1995) and reviewed by Coombe (1995). The stages and relationships are defined by the term grapevine phenology, which is the study of the timing of natural phenomena (Pearce and Coombe 1994).

In Australia, extensive studies of phenological models by Coombe (1995) served to identify and correct problems or interpretations, namely the lack of intermediate growth stages in previous models. The modified E-L system (Coombe 1995), since its modifications, has been widely adopted throughout Australia.

The modified E-L system (Figure 1) has in total 47 stages of continuous grapevine development and, unlike previous classifications; the modified E-L system takes into consideration winter bud and senescence periods as defined by an E-L number. For example, (E-L 1) is winter bud, and (E-L 47) is end of leaf fall.

When examining phenology, timings of budburst (E-L 4), flowering (E-L 19), veraison (E-L 35) and harvest (E-L 38) (Figure 1) are of particular significance.

The collation of growth data is essential to determine the growth stages of the vine; this resource enables knowledge for prediction of future key growth phases. It is important, when interpreting these stages, factors such as variety, climate (including temperature) and geographic location are considered (Swanepoel et al. 1990, Lavee and May 1997, Jones and Davis 2000). It is also important to note that environmental practices such as water stress or pruning time (Pearce and Coombe 1994) and genotype of variety (May 2004) will influence the timing of phenological events

In most Australian vineyards, budburst occurs in September, flowering in November / December, veraison in January / February and harvest anywhere from February through to May, depending on region, wine style and variety (Pearce and Coombe 1994). However, the validation in the timing between growth stages can range from 3 weeks for budburst, 2 weeks for flowering, 4 weeks for veraison and 7 weeks for harvest (Pearce and Coombe 1994).

Flowering occurs after a considerable period of inflorescence development from E-L 12 through to E-L 19. Flowering dates regionally are relatively consistent and linked to the local climatic conditions. The interval between budburst and flowering is generally 60 days (depending on the date of budburst) (Pearce and Coombe 1994). Coincident with flowering is the first major period of root growth in the season (Pearce and Coombe 1994).

After flowering, the next major phenological stage of development is veraison; the timing of this differs for each variety (Pearce and Coombe 1994). Veraison occurs approximately midway through berry formation and signals the start of the ripening phase, whereby the berries increase in size and accumulate sugar and anthocyanins along with other aroma and flavour compounds (Pearce and Coombe 1994).

The phenological stages that denote harvest are E-L 38-39; however, harvest occurs when bunches reach a desirable sugar (Brix or Baume). Therefore, the duration of this phase is subject to the wine style and variety. For whites, this sugar accumulation period is generally less than for reds.

The aim of phenological studies is to describe the variation in timing and duration of events. As mentioned earlier, the timing of these key phenological stages is not defined and varies by variety, region and climate. Jones and Davis (2000) propose that the interactions between these key phenological events (climate and rate of phenological development) are more important than the actual timing of each individual event. For example, they associate short intervals with optimal temperature conditions that are accompanied by rapid physiological growth and differentiation. Conversely, long intervals are associated with poorer climatic conditions that lengthen the interval between phenological stages and thus maturation date (Jones and Davies 2000).

Characterisation of the length and duration of key growth phases enables a better understanding of the climatic conditions during the season. The data suggest that each phenological growth stage not only interacts with the current climatic conditions at that particular time but also each phenological growth stage is influenced by the conditions of the

previous stage. Further to this, the rate of progress between each phenological stage in an ungrafted scion is a result of the genotype (Hamilton and Coombe 1991).

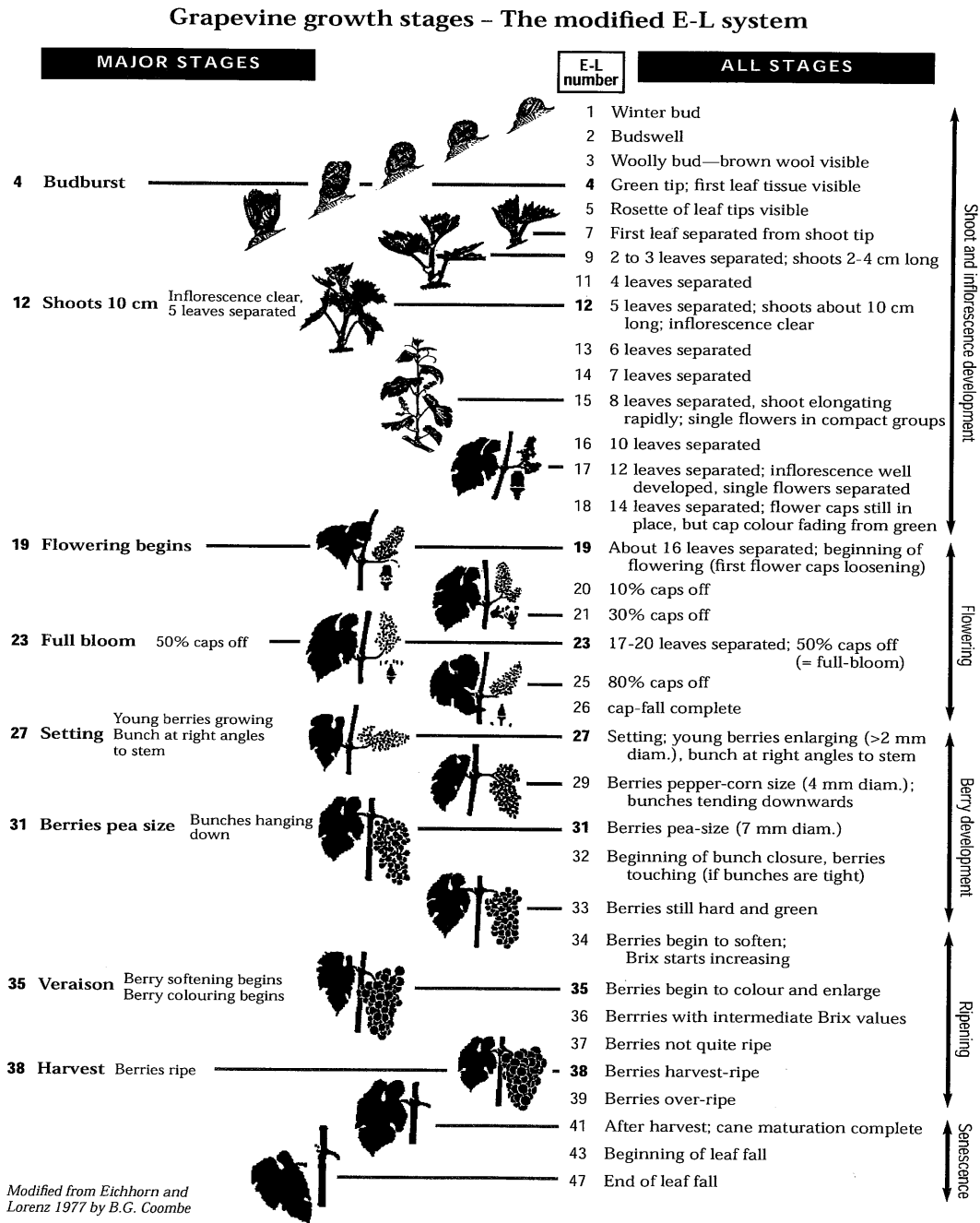


Figure 1. The modified E-L system by Coombe 1995. This system has in total 47 continuous stages of grapevine development. When examining phenology key timings of budburst (E-L 4), flowering (E-L 19), veraison (E-L 35) and harvest (E-L 38) are of particular note and significance.

3. Grafted vine phenology

The influence of rootstocks on the behaviour of the scion is relatively unknown. However, from the studies thus far performed, it is clear that rootstocks exert a certain influence on the performance of the scion (Smith and Holzapfel 2002).

Grafting is the uniting of two pieces (scion and stock) of living plant tissue (Giorgessi et al 1996). The upper part of the graft combination is referred to as the scion; the lower portion including the root is known as the stock (Nicolas, Champini and Cirami 1994). The purpose of grafting can be varied and may include the requirement to tolerate certain soil conditions including phylloxera and other pests and diseases, to advance or retard maturity, or to simply change the variety (Nicolas, Champini and Cirami 1994).

Most of the literature recognises the lack of understanding of the relationship between the rootstock and scion. Streigler and Howell (1991) tried to elucidate the relationship by characterising a change to the scion as being a primary or secondary effect of the rootstock. For example, a primary effect from the rootstock would relate more specifically to the vine function, such as water uptake and nutrient translocation as a result of a change in vine physiology with the change of root system. A secondary influence on the scion would be on vine size and internal canopy shading.

Stefanini et al. (1996) measured a series of rootstocks and drew correlation between increased vigour and advanced maturity. Sepulveda (2005) found discrepancies as to whether this change in plant growth response (i.e. vigour) was directly a result of grafting a rootstock to a scion or a more indirect effect of a change in canopy architecture and resultant increases or decreases in vigour.

Evidence clearly shows an interaction between the two systems (rootstock and scion) particularly with regards to water uptake, the ability of the grafted combination to increase or decrease uptake and translocation of nutrients and vigour conferred to the scion as a result of rootstock (Streigler and Howell 1991, Whiting 1998, McCarthy et al. 1997, Keller 2001, Walker et al. 2000).

Thus, based on previous observations relating to rootstock effects on vigour, nutrient status, and an ability to exclude or uptake nutrients, rootstock genotype should also be able to change and influence the vine phenology of the scion.

Thus it is postulated that phenology will be affected by a combination of factors, including rootstock, soil type, climate and scion variety (Smith and Holzapfel 1991) Further to this, the presence of any growth-limiting pests in the soil (Sepulveda 2005) will also determine the performance and potential of the rootstock depending on the rootstock's ability to resist the pest / environmental condition present.

4. Conclusion (future directions)

Ultimately, it is safe to assume that grafting will result in a change in the functioning of both the rootstock and the scion. Understanding grapevine phenology is of interest to the viticulturalist because it enables predictions of important events like flowering, veraison and harvest throughout the seasonal calendar.

The experience of rootstocks influence on vine nutrient status and water use efficiency (Streigler and Howell 1991, Whiting 1998, McCarthy et al. 1997, Keller 2001, Walker et al. 2000) suggests that rootstock's may effects the phenological cycle of the vine. Limited evidence suggests that there may be a relationship between rootstock and scion, and

consequently a change in the rate and timing of key phenological stages like budburst, veraison and harvest; however further exploration of this topic is required.

The important information perhaps to be gained from determining changes in phenology with rootstocks is the timing of each individual growth phase specific to the variety, region and climate as this will undoubtedly influence viticultural management; it could even help overcome problems associated with climatic instabilities such as delayed ripening or budburst during severe frost conditions.

However, what is more important is that these processes are documented on a region by region basis as it is clear that duration of these events varies depending on the environment and climatic indices, along with scion variety.

In conducting this review, it is clear that there may not be one obvious and defining process, but rather a contribution of factors when determining what influences grapevine phenology (with a grafted rootstock / scion combination). The fact that the environment or more specifically, soil, climate, nutrient status, pest and disease presence, along with the scion variety itself, contribute to phenology in ungrafted vines suggests that adding an effect of grafting would more than likely also contribute to changes in the scion phenology, particularly the scions ability to ripen and mature. Further research needs to be done to define the influence that the rootstock has on this complex process.

Key phenological timings of grafted and non grafted vines need to be studied. Preliminary research shows that budburst timing varies between rootstock cultivars (Cox unpublished data) yet whether this extends to grafted scions requires further study.

Research on understanding rootstock / scion phenology would provide powerful insight and understanding to further aid in managing grafted vines within the viticultural seasonal calendar.

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