Characteristics of Successful Planting Material: Evaluation of Young Material

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Introduction
Economic viability of new vineyard plantings is dependent on rapid establishment of a uniform, productive vineyard. There will always be large differences in growth and establishment due to the effects of the environment (climate, soil, season), time of planting, variety and rootstock vigour differences, propagation and grafting techniques, training and trellising methods. Commercial experiences in warm irrigated vineyards have shown that it is possible to replant existing vineyards and miss only one crop, e.g. 25 tonne/ha of Colombard in year 2. In cooler regions (e.g. Coonawarra) a crop in year 3 (e.g. 5 tonne/ha of Chardonnay or Cabernet) is considered essential for success. This paper discusses some of the factors that may influence the performance of young vines in both experimental and commercial situations.

Assessment of source material
Where possible source material of both rootstocks and scions should be from certified sources. The use of inferior material may have detrimental effects during propagation and early establishment and in final vineyard performance. The major factors which should be considered are provided below.

Variety
Have the source blocks been checked for trueness to type and off types, and have mutant bud sports been eliminated? Some varieties, particularly rootstocks, are difficult to separate and have been confused in the past, e.g. the V. champini rootstocks, Ramsey and Dogridge, which have very different performance characteristics. Identification techniques, such as DNA typing, are likely to play an important role in future certification programs (Thomas, Habilii and Scott 1992 and Thomas, Cain and Scott 1994).

Clone
For most of the important commercial varieties a range of certified clones are available. Most clonal differences appear to be associated with infection by virus-like organisms, e.g. leafroll viruses, rather than genetic in origin (Thomas, Habilii and Scott 1992 and Clingeleffer and Scott 1994). A knowledge of vine health status and the impact on production and quality must be considered in assessment of appropriate clones. Molecular techniques, e.g. serological ELISA or dsRNA tests used for the detection of leafroll virus, will provide rapid diagnostic tools compared with traditional virus indexing (Rezaian et al. 1992 and Habilii et al. 1992). A checklist of the factors important in the assessment of clones is given below; this information may not be available from detailed scientific evaluation but could be available from commercial experiences in similar environments. They include:

- Suitability to the environment: European clones which have been selected in completely different environments using very restrictive management practices may not succeed or may perform differently in the various regions of Australia (Possingham et al. 1989). For example Ewart and Sitters (1989) and Noon et al. (1989) give quite different performances results for Pinot Noir clones grown in the Barossa Valley or in Great Western. Furthermore, selections which produce smaller loose bunches may have advantages in disease prone districts.

- Product style and quality: While productivity has been the main selection criteria in clonal trials, the impact on wine quality and styles must also be considered. For example, Cirami et al. (1984) found large differences in the level of anthocyanins and phenolic content of Pinot Noir clones, and suggested that lesser pigmented clones may be suited to Champagne-style wines and the more pigmented clones to red wine styles.

- Vine management considerations: Research has shown that traditional severe pruning may limit the production of improved clones (Clingeleffer 1988 and Clingeleffer and Krake, 1992). A slight pruning techniques (i.e. hedging or minimal pruning) are largely used for wine production in Australia (Clingeleffer 1995) the performance of clones under these management regimes should be understood.

- Interaction with rootstock: Rootstocks are now being used in Australian viticulture for vigour and productivity enhancement and tolerance of soil-borne pests (nematodes and phylloxera). While it is generally recognised that scion/rootstock compatibility must be considered in the selection of material, recent studies indicate that clonal interactions with rootstocks are likely to be of significance.

For example, preliminary studies with Sultana clones suggest that performance rankings between selections are different depending on whether they are on own roots or grafted to Ramsey (Clingeleffer 1995). It is likely that low yielding, low yielding clones discarded in selection trials on own roots may be superior in performance on rootstocks.

In particular, clones with small bunches may offer distinct advantages in disease management when grafted on rootstocks. For example the low-yielding, small bunch Cabernet Sauvignon clone (C7 V5) produced acceptable yields compared to SA 126 and SA 125 when grafted on Ramsey (Possingham et al. 1989).

Treatment of material
Chemical treatment may be used to control fungal pathogens and enhance performance during propagation, for example the use of Phomopsis to protect against Botrytis cinerea. Hot water treatment (Nicholas et al. 1992) may also be used to destroy pests and pathogens, e.g. phylloxera, nematodes, the phytoplasma flavescence doree, crown gall (Agrobacterium) and as yet other unknown endophytic microflora.

It is likely that the current practice of a 50°C hot water treatment for 30 minutes, used as a crown gall treatment, (Burr et al. 1989), may be modified to control the phytoplasmas associated with Australian vine yellows (Padovan et al. 1995). Molecular diagnostic tools will be of importance for routine
screening of material for such pathogens, e.g. serological ELISA tests for Agrobacterium (Ophel et al. 1990, Steele Scott et al. 1993) and PCR techniques for phytoplasmas such as vine yellows (Padovan et al. 1995).

Wood quality: The selection of only the best material is a prerequisite for successful propagation and young vine growth. Thus it is essential that quality be maintained, despite the shortage of material of ‘in demand’ varieties. A number of parameters must be considered in the assessment of wood quality. They include:

Morphology: Cuttings are best made from moderately vigorous, well-matured canes which have an ample supply of stored foods to nourish the developing roots and shoots until the new plant becomes self-sustaining (Nicholas et al. 1992). Well-matured cuttings usually have deep brown colour and a small pith-to-wood ratio. Excessively long internodes indicate rapid growth and development of canes in a shaded environment with low carbohydrate status, and should be avoided. Care must be taken to avoid selection of cuttings from poorly matured, distal parts of canes.

It has been reported that cuttings taken from weaker shoots produce less reliable rooting (Considine 1992), and thus should be avoided. However, this may not be true for the small, close-noded, well-matured shoots produced by minimal pruned vines which have adequate carbohydrate levels (Sommer and Clingeleffer 1995, see discussion below).

Nutritional status of mother vines may affect rooting and early vine growth. Poljak et al. 1997 found that carbohydrate development was reduced by increasing N, P and K levels in source vines (i.e. mean negative correlation coefficients of 0.32, 0.57, 0.81 respectively for cane content and carbohydrate development of two rootstocks SC and SO4). Optimum cane K levels for callus development were found to be in the range of 0.3–0.5%. Poor rooting with high nitrogen fertilisation and high cane nitrogen status has also been reported by others (Nicholas et al. 1992 and Habb et al. 1990).

Time of cutting: Blennerhassett and Considine (1978) and Considine (1982) indicate that cuttings should be taken as early as possible after leaf fall to maintain high moisture content and optimum carbohydrate status (see below). This approach is facilitated by the use of cold storage. Cold storage also provides a cold treatment to break dormancy, particularly of rootstocks such as Ramsey which require longer periods of cold to break dormancy, and good photosynthetic conditions during 1992/93’s very wet and cool late spring/early summer. The low carbohydrate values in the post flowering period in 1992 support this view, i.e. only 60% of 1991.

Carbohydrate status: The young plant is dependant on stored carbohydrates for growth for a period of 12–14 weeks before photosynthetic sources from new leaves are adequate (Uys and Orffer 1993). The main storage forms of carbohydrates are starch and soluble sugars. While there is general agreement in the literature that levels of total carbohydrate around 12% are required, high levels of soluble sugars have been negatively correlated with propagation success rates (Treeby and Considine 1991, Mannini and Schneider 1988). However, complex enzymatic techniques are required to accurately assess carbohydrate status. Considine (1982) suggested that a simple starch-iodine test be used as an indication of total carbohydrate content. However, because of the conversion of starch to soluble sugars during the winter its application should probably be restricted to late autumn sampling.

In summary cuttings should have a high total carbohydrate status and a high starch to sugar ratio. The data provided in Table 1 show that spur and minimally pruned vines which produce small diameter, close-noded shoots, had similar total carbohydrate levels, but that there was a difference in the starch to sugar ratio (i.e. 1.6 and 1.2 for spur and minimally pruned vines, respectively). It is likely that cuttings from minimally pruned vines would be satisfactory for use as scion material for grafting. They would be less reliable as rootlings due to the compounding effects of the lower starch to sugar ratio and small cutting diameter, hence lower absolute total carbohydrate available to support growth.

It should also be noted seasonal effects may influence the carbohydrate level of cuttings. The results in Table 2 for one-year-old Cabernet Sauvignon show higher dormant levels in the winter of 1991 and 1992 (despite a very high crop in that season) than in 1993. This was probably due to the combined effect of disease (leaf loss due to downy and powdery mildew) and poor photosynthetic conditions during 1992/93’s very wet and cool late spring/early summer. The low carbohydrate values in the post flowering period in 1992 support this view, i.e. only 60% of 1991.

Assessment of young vines: This part of the paper provides details of comparative studies arising from CSIRO research involving evaluation of young vines, providing a basis for discussion on changes in carbohydrate composition in young vines which will then be related to recent poor growth in commercial situations.

Evaluation of grafting success, early growth and field performance of Cabernet Franc grafted to Ramsey from various sources. Bench-grafted plants were produced using leafroll-free Cabernet Franc as the scion with Ramsey rootstock from 3 sources, i.e. commercial certified material, hot water treated commercial material (50°C, 30 min.) and cuttings from mother vines established from tissue cultured material (Clingeleffer and Possingham 1990). The two latter treatments were included with the aim of reducing or eliminating crown gall, a gro-

<table>
<thead>
<tr>
<th>Season</th>
<th>Total carbohydrate (% dm)</th>
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<tbody>
<tr>
<td>1991 Dormant, Winter</td>
<td>10.7</td>
</tr>
<tr>
<td>1991 Post Flowering, Full Canopy</td>
<td>4.6</td>
</tr>
<tr>
<td>1992 Dormant, Winter</td>
<td>9.4</td>
</tr>
<tr>
<td>1992 Post Flowering, Full Canopy</td>
<td>2.8</td>
</tr>
<tr>
<td>1993 Dormant, Winter</td>
<td>7.4</td>
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Table 2. Carbohydrate status over three seasons of one-year-old of Cabernet Sauvignon. Results are combined over two pruning treatments (cane and minimal) and two rootstocks (own roots and Ramsey) as differences were not significant. Adapted from Sommer and Clingeleffer 1995 (in press).
The best plants from each treatment were established in the field and having the lowest mean lignified shoot length. When have been slightly detrimental, producing fewer strong vines material gave a superior product. The heat treatment may vines with strong growth showed that the tissue-cultured treatment. The mean length of lignified shoot and per cent of successful grafts continued to be highest with the tissue cultured material. The number of success rate over the commercial material. Callus development in most sources of rootstock material (Ophel 1988).

Adapted from Clingeleffer and Possingham 1990.

<table>
<thead>
<tr>
<th>Ramsey Source</th>
<th>% Successful</th>
<th>Callus score</th>
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<tbody>
<tr>
<td>Commercial</td>
<td>80</td>
<td>2.9</td>
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<tr>
<td>Hot water</td>
<td>82</td>
<td>3.3</td>
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<tr>
<td>Tissue cultured</td>
<td>94</td>
<td>4.7</td>
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<table>
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<tr>
<th>Ramsey source</th>
<th>% Successful</th>
<th>% Vines with strong growth</th>
<th>Mean lignified shoot length (cm)</th>
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<tr>
<td>Commercial</td>
<td>77</td>
<td>20</td>
<td>7.3</td>
</tr>
<tr>
<td>Hot water</td>
<td>75</td>
<td>16</td>
<td>6.9</td>
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<tr>
<td>Tissue cultured</td>
<td>82</td>
<td>35</td>
<td>10.0</td>
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<table>
<thead>
<tr>
<th>Ramsey source</th>
<th>Clone</th>
<th>% of fully established vines</th>
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<tr>
<td></td>
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<td>Untreated</td>
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<tr>
<td>Commercial</td>
<td>H4/R</td>
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</tr>
<tr>
<td>Hot water</td>
<td>H5/R</td>
<td>55</td>
</tr>
<tr>
<td>Tissue cultured</td>
<td>H5V8/R</td>
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<td></td>
<td>H5V8/TC R</td>
<td>-</td>
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<table>
<thead>
<tr>
<th>Season</th>
<th>Field-grafted</th>
<th>Bench-grafted</th>
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<tbody>
<tr>
<td></td>
<td>- Hot water</td>
<td>+ Hot water</td>
</tr>
<tr>
<td>1993</td>
<td>15.0</td>
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</tr>
<tr>
<td>1994</td>
<td>30.2</td>
<td>32.1</td>
</tr>
<tr>
<td>1995</td>
<td>28.1</td>
<td>30.1</td>
</tr>
</tbody>
</table>

Table 3. Percentage of successful grafts and score of callus development for Cabernet Franc bench grafted to Ramsey rootstock from various sources.

(Callus score, 1 = no callus, 3 = callus obvious on one side, 5 = callus on both sides of the graft union).

A adapted from Clingeleffer and Possingham 1990.

Table 4. Percentage of successful grafts, percentage of vines with strong growth (i.e. >12 cm of lignified shoot) and mean lignified shoot length for Cabernet Franc bench grafted to Ramsey rootstock from various sources and hardened off in a shade house environment.

A adapted from Clingeleffer and Possingham 1990.

Table 5. Yield (1993–95) and pruning weight (1993) of Cabernet Franc bench grafted to Ramsey from various sources, planted in 1990 and developed as spur pruned vines, except in 1995 when half were trained to minimal pruning.

Table 6. Effect of hot water treatment of cuttings on establishment of bench grafted Sultana/Ramsey(R) combinations. A further treatment of the leaf roll virus free Sultana H5V8 clone grafted on Ramsey sourced from tissue cultured material (TCR) is also included. The vines were bench grafted and planted in spring 1993. Establishment was assessed in winter 1992. Vines with 4 canes were classified as fully established.

Table 7. Comparison of yields (1993–95, tonne/ha) of field-grafted and bench-grafted vines (with and without hot water treatment of cuttings) of Sultana/Ramsey combinations.

There was no significant difference in productivity (Table 5). Overall the results indicate significant advantages in the use of the tissue-cultured source of Ramsey when producing bench graftlings. The field performance however was unaffected, possibly due to a build up in titre of A T3 or other endophytic microflora.

Effect of hot water treatment on establishment of bench-grafted Sultana/Ramsey combinations. The effect of hot water treatment (50°C, 30 min.) to reduce A T3 was studied in a comparative trial with the Sultana clones H4 and H5 which are both infected with mild leafroll virus and the leafroll-free H5V8 produced via tissue culture. A further treatment where the H5V8 was also grafted to Ramsey from a tissue-cultured source (see previous study) was also included.

The vines were bench grafted in September, planted directly into the field in December and trained to four canes on a high (1.8 m) 0.3 m T-trellis. Hot water treatment of the material before grafting improved establishment of all three clones (Table 6). The tissue cultured material produced similar results to the heat treatment. The results in Table 7, which also includes data for a field-grafted treatment, indicate that despite the better establishment, productivity was largely unaffected by the heat treatment. The yields of the field-grafted treatment were lower than the bench grafted vines in each of the three seasons.

Changes in carbohydrate status and plant tissues during growth of Ramsey rootlings. Successful propagation of a cutting is dependent on stored carbohydrates (Uys and Orffer 1983). Data adapted from Uys and Orffer (1983) is presented in Figures 1 to 5 to demonstrate changes in carbohydrate status of plant tissues during growth of Ramsey rootlings in a nursery situation. Similar results have also been reported for grafted vines (Schaefer 1978).
Figure 1 shows the loss in cutting (stem) weight as carbohydrates are utilised for root and shoot growth until November. A steady increase in stem dry weight occurs thereafter as leaves export carbohydrates. Root weight rapidly increased from November, reaching a maximum in March with a total weight similar to the stem. Shoot weight increased rapidly from November to February and continued to show a steady increase into winter. By contrast the rapid increase in leaf weight peaked in January and decreased rapidly with defoliation from March to May.

Changes in plant carbohydrate levels during cutting establishment are presented in Figure 2. There is a rapid loss of carbohydrate (i.e. 12% to 3%) from the stem during early growth, i.e. a August-November, followed by accumulation from photosynthetic sources, i.e. up to 12% in April. Carbohydrate levels in the new developing shoot were maintained at around 8%. There was a rapid increase in root carbohydrate level throughout the main period of growth, November to February followed by a decline over the winter period. The maximum level in the roots was twice that found in the shoot or stem. The total carbohydrate stored in the various plant parts. (Figure 3), show that the roots rapidly become the main storage organ for carbohydrate from December due to the combined effects of root weight and the high carbohydrate level, which mainly consists of starch (Uys and Orffer 1983). These authors suggest that roots should not be trimmed prior to planting so that the main source of carbohydrates is maintained to help support growth.

A comparison of total plant weight and total carbohydrate accumulation (excluding leaves) in Figure 4 shows that, generally, total plant carbohydrates mirror plant growth, except during the loss in plant weight with defoliation in autumn, but carbohydrates decrease over the winter period. The ratio of total plant carbohydrate (excluding leaves) to plant weight is presented in Figure 5 as an indication of overall plant carbohydrate status. The results show a rapid drop until November until accumulation begins with the development of photosynthetically active leaves. The high levels were achieved because of the cessation of leaf growth in January and root and stem growth in March.

Recent experiences with young vines

Nurserymen and growers have reported very poor budburst and growth of young vines in the spring of 1994. A typical seasonal factors appear to be associated with the restricted spring growth, i.e. extreme drought conditions over the preceding season and into winter, a mild autumn which favoured ongoing vine growth and very cold periods with frosts in late winter and spring (Mattoschoss et al. 1995). A part from the direct effects of low soil moisture and low soil temperatures on root activity, factors which may also have been involved in the restricted growth include:

- Drought effects on previous growth and carbohydrate accumulation: Monitoring of plant water use in a number of trials indicated that there was a high demand for water in the autumn period, particularly during the mid growing conditions in April. If irrigation were not supplied to young vines, particularly those which had some crop in the previous harvest period, it is likely that plant growth, particularly the roots, and total carbohydrates would have been restricted. Ruhl and Aikens (1999) showed that drought reduced the total amount of stored carbohydrate available to support growth in spring. Furthermore these authors demonstrated that even temporary periods of drought followed by adequate water supply had an effect on total carbohydrate accumulation.
- Carbohydrate status: As indicated previously, vigorous vines, particularly those on Ramsey rootstock can be rapidly brought into production through rapid establishment of the framework of the vine. ‘Forcing’ early development by close attention to irrigation and nutrient supply is frequently used to facilitate this process. In 1994, because of the mild conditions, growers were able to maintain the growth of young vines late in the season. In contrast to the examples presented earlier where growth stopped in February (Figure 1), it is likely that carbohydrate partitioning would have been toward supporting new growth rather than accumulation in the roots as in Figure 2 and would have given a low carbohydrate:plant weight ratio. This low carbohydrate status may have limited growth in spring and contributed to reduced cold tolerance (see below). It should be noted that much of the wood laid down as a result of the rapid late autumn growth was not fully matured, i.e. poorly lignified with a high pitch:wood ratio.
- Cold tolerance: Green tissue of grapevines is easily damaged by cold below -5°C. (Winkler et al. 1974). By contrast dormant wood of V. vinifera can tolerate much lower temperatures before mechanical injury to the tissue occurs, for example Meiering et al. (1980) found that mechanical injury occurred to the trunks of Gewurztraminer vines between -10°C and -25°C. Tolerance to cold was dependent on low moisture content and high carbohydrate status, and it was concluded that the storage carbohydrates and proteins act as anti-freeze to reduce the damage due to cold in winter. Transposing these observations to the conditions experienced in Australia last season, it is likely that low carbohydrate status was confounded by early good shoot growth (i.e. air temperatures above 10°C. Winkler et al. 1974). Poor quality wood (i.e. ophyl) would therefore have been more susceptible to the low terrestrial temperatures frequently recorded at the time (Mattoschoss et al. 1995).

References


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yet poor material may have a lasting influence on vineyard productivity. Make sure that the nursery has soil tested for nematodes regularly and find out what program, and its effectiveness, is used by the nursery to prevent a build-up of soil-borne pathogens.

Neglecting to test soil for nematodes before purchase of land or planting to vines has also resulted in vineyards being set-up in ground heavily infested with nematodes, risking poor establishment and reduced productivity. In many cases vineyards have been planted in ground previously used either for grapevines or for other horticultural crops (e.g. citrus, stone-fruit, vegetables) and field crops (e.g. lucerne, clovers), and infested with root-knot, citrus or other nematodes, such as lesion and stubby root nematodes. We know very little about the resistance of vines to some of these nematodes, yet have been unable to take up the opportunity offered by such situations to learn more, due to declining research support in this area. Similarly, planting has occurred in ground likely to be heavily infested with soil-borne pathogens such as Fusarium, Verticillium, Phytophthora, Pythium and Rhizoctonia species, and other fungi. The effects of these pathogens on young vines growing in the enormous variety of soil types and climates occurring under Australian viticulture is not known. However, we have shown that some R. solani races commonly associated with vegetables can damage young vines.

Pre-planting treatments (e.g. extended fumigation or cropping to non-host cover crops; soil fumigation) and, especially, the use of grafted, nematode-resistant root stocks, are often more effective strategies against nematodes than annual application of nematicides to soil after planting. Use of chemicals, both fumigants and nematicides, is under threat because of environmental and health concerns. Biofumigant cover crops and antagonistic micro-organisms are being investigated for control of nematodes but are not yet in commercial use.

Use of resistant rootstocks is the most cost-effective option for control of nematodes where other considerations permit their use, viz. soil type, vine vigour, grape yield/quality, however supply of grafted vines has not kept up with demand. This is a problem requiring attention given the plantings projected to occur into the next century under the national industry plan. Also, currently available stocks possess resistance to only a limited range of nematodes, mainly root-knot nematodes, and evolutionary development of these nematodes poses a threat to such resistance in the longer term.

Further research is needed to identify and develop sources of resistance, and to find simpler ways of utilizing such resistance than by grafting rootstocks.

Conclusions

Planting material can introduce diseases and nematodes to vineyards. Leading both to direct losses in production and to higher operating costs. It is particularly important that healthy material be used in new districts and in ground not previously planted to grapevines. Use only certified material from vine improvement schemes and avoid material with obvious symptoms of disease. Test soil for nematodes before purchasing land or planting vines, and use nematode-resistant root stocks where appropriate. Clean machinery before moving between vineyards. Carefully monitor developing vineyards for disease and apply fungicides as needed to ensure strong, healthy growth.