Horticulture Innovation Australia

Final Report

Producing High Value Dried Grapes – Stage 2

Phil Chidgzey
Dried Fruits Australia Inc

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DG13006

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Level 8, 1 Chifley Square
Sydney NSW 2000
Tel: (02) 8295 2300
Fax: (02) 8295 2399

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Summary

The main goal of this project was to develop best practice management information for use by growers, enabling the Australian dried grape industry to consistently produce high quality, light-coloured Dried Vine Fruit (DVF).

Specifically, through the 3 project activities, the project sought to achieve the following objectives:

- To build on a previous literature review entitled "The Influence of Vineyard Factors On The Colour Of Dried Vine Fruit At The Farmgate" by undertaking a full literature review to capture additional information from a range of industry sources, publications, published papers, project reports and direct feedback from industry and identify knowledge gaps and changes that need to be made to current management practices.
- To use information from the full literature review and final report of the stage 1project, to produce an updated Best Practice Guide which provides growers with clear recommendations for the consistent production of high quality, light DVF.
- To develop improved trellis drying management systems for adoption by growers that improve the likelihood of producing quality, light coloured fruit by maximising the exposure of drying grapes to higher day time temperatures for longer and minimising the exposure of the fruit to the vagaries of the weather during the drying process. The three on-farm trials to be conducted are:

  Trial 1 Advancing maturation with potassium (to assess the impact of potassium sprays on maturity of dried grape varieties of Sultana& Sunmuscat)

  Trial 2 Drying emulsion rates to improve drying (to assess the impact of drying emulsion strength on the time needed to dry fruit to harvestable moisture content)

  Trial 3 Improving drying conditions in the vineyard (to assess the impact of vineyard floor management on drying conditions in vineyards for the production of dried vine fruit)

The “Producing High Value Dried Grapes” project involved 2 stages over the period 2014-2016.

The Stage 1 project began in 2014 with the initial focus examining the relationship between berry maturity at the time drying was initiated and final dried grape colour. It confirmed that weather during drying was the biggest influence on final dried grape colour, but when this factor was removed, there was no colour penalty associated with lower maturity from large crop loads.

The use of plastic covers on summer- pruned sultanas and Sunmuscat was also investigated to gain some practical experience on how covers would work on Swingarm trellis and to assess the impact on the microclimate in the drying canopy. Covers did not prevent drying grapes from being exposed to high ambient relative humidity. Final dried grape colour was unaffected by covers, although colour intensity was greater with covers.

The stage 1 report found that taking advantage of generally warmer conditions in February would seem advantageous. Therefore, accelerating ripening and optimising drying conditions to increase moisture loss from grapes after summer pruning would seem to be logical priority areas for further research.

The Stage 2 project had several component activities including the completion of a full literature review entitled “Producing High Value Dried Grapes”, the preparation of a three3 part Best Practice Guide for growers and the conduct of three on-farm trials looking at ways of improving the likelihood of growers

being able to produce quality, light coloured dried fruit by reducing the time of exposure to adverse weather conditions during the drying process.

The Stage 2 project was undertaken with a staged approach that began with the completion of the full literature review and preparation of an updated "Best Practice Guide", followed by the careful consideration of the findings arising from the stage 1project and the full literature review. The "Best Practice Guide" for the production of high quality, light coloured, DVF in Australia incorporated the latest information from the literature review, stage 1project findings and industry feedback.

An early project review process (stop/go) was undertaken and assessed the findings of the full literature review and stage 1project and used to determine that the following additional on-farm trials should be conducted in the 2014/15 season:

Trial 1 Advancing maturation with potassium (from mid- January to mid-February 2015)
Trial 2 Drying emulsion rates to improve drying (from mid- February to early April 2015)
Trial 3 Improving drying conditions in the vineyard (20 December 2014 to late April 2015)

While the 2014/15 harvest season provided growers with excellent drying results, the weather conditions were not considered to be 'normal' for a typical drying and harvest period. These conditions meant that the rationale behind the field trials, which sought to more rapidly dry grapes by increasing exposure to higher daytime temperatures and thus reducing exposure to adverse weather, could not be fully tested.

As a result, DFA gained approval to repeat the on- farm trials in during the 2015/16 season, when an 'average season' was likely with drying interrupted by rain event(s) enabling the original project objectives to be tested. Unfortunately, from a research perspective, the 2015/16 season was not an “average season” but rather another season that provided excellent drying conditions, again preventing the rationale behind the field trials from being fully tested.

Outputs from the stage 2 project included:

- a full literature review report entitled “Producing High Value Dried Grapes” being produced and made available to dried grape growers and Australian processor/marketers
- a three-part Best Practice Guide being produced and distributed to dried grape growers and Australian processor/marketers
- Detailed reports on the on-farm trials conducted in both the Stage 1 & Stage 2 projects
- A series of research updates published in The Vine magazine, circulated to all dried grape growers
- Research Update presentations at several industry forums during 2015 & 2016

Outcomes from the stage 2 project have included:

- More informed growers and processors as a result of having access to updated reference material relating to the production of high quality, light dried grapes
- Increased uptake of best practice management systems by growers, using Best Practice Guides
- Better understanding amongst growers and processors of factors affecting maturation and speed of drying

Recommendations for further R&D

- The industry may want to further investigate the influence of air movement and drying rates with close rows and overhead pergola systems compared to standard or wider rows.

Keywords

dried grape; dried vine fruit; Sultana; Sunmuscat; drying; best practice guide; drying emulsion; microclimate; maturity;

Introduction

The 2012-2016 Dried Grapes Strategic Investment Plan stated that the market outlook over the next 5 year period was likely to be very positive. World supply was relatively stable, demand strong, and prices were at levels that could support viable production and processing operations.

Further, estimates from DVF processors/marketers suggested that there was a potential market for up to 5,000 tonnes of high quality, light coloured DVF per annum, provided the industry could maintain a consistent supply over a period of years.

The focus on high quality, light coloured DVF production so as to achieve product differentiation in targeted niche markets would provide the Australian industry with an opportunity to achieve improved higher margin product sales and sustainable growth.

However, the Australian industry's greatest challenge over the previous 5 years had been the industry's inability to produce sufficient quantities of suitable fruit.

Historically, severe adverse weather conditions during maturation/drying/harvesting had occurred once every 5 years. More importantly, only 11out of the last 66 years had not had rainfall events significant enough to darken drying fruit (>5mm during February and March).

Climate variability was accepted as being on the increase, with enormous swings in climatic conditions likely over the foreseeable future leading to more frequent weather events likely to damage DVF.

Without some modification or adaptation, the suitability of current trellis drying practices to consistently deliver high quality, light-coloured DVF under these circumstances was considered to be highly doubtful.

In response to this urgent need DFA established a working group in early 2013 to identify issues or limitations affecting the industry's ability to consistently deliver a reliable quantity and quality of DVF. As part of that process, the working group considered the findings from a review of published scientific literature in this area entitled ''The influence of vineyard factors on the colour of dried vine fruit at the farm gate") and agreed that the "Producing high value dried grapes- stage 1" project should be undertaken with a focus on the following aspects of production:

- determining the appropriate maturity levels to optimise initiation of the drying process, and
- using plastic covers to protect grapes drying on the trellis

Subsequently, the DFA in consultation with the Project Management Committee for the stage 1 project agreed that the "Producing high value dried grapes - stage 2" project should be commenced as soon as practicable, in a careful, staged manner.

The first component of this project was a full literature review, followed by the preparation of an updated "Best Practice Guide" incorporating the latest information and industry knowledge.

The final component involved the conduct of 3 field trials directly related to the broad objective of improving the likelihood of growers being able to produce quality, light coloured dried fruit by reducing the time of exposure to adverse weather conditions during the drying process.

The On-Farm Trials

Trial 1 - Advancing maturity

Given the relative proportions of water and soluble solids in fresh grapes, the amount of sugars can increase significantly as grapes mature, but the yield of fresh grapes per ha not change appreciably. Drying ratios (*i.e*. tonnes of fresh grapes: tonnes of dried grapes) are a function of the level of soluble solids (mainly sugars) in grapes at the time of harvest/cutting. As the amount of soluble solids in grapes increases as grapes mature, the drying ratio can decrease from 4 or greater at xx ^{o}Brix to 3 or so at yy ^{o}Brix. The lower the ratio, the greater the yield of DVF per ha. Thus, there is a strong incentive for DVF producers to maximise berry soluble solids levels before initiating the drying process. However, the likelihood of suitable drying weather diminishes as the season progresses past mid-March or so. Advancing maturity by several days could enable the initial breakdown to take place under more favourable drying conditions. This would be greater advantage for Sunmuscat which matures later than Sultana in any case.

Research in California has suggested that maturity of Thompson seedless (syn. Sultana) could be advanced by around a week to 10 days by applications of a potassium spray formulation. The formulation contains 24% potassium (K) chelated by amino acids. The aim of this component of the project was to test the hypothesis that applying this formulation advanced maturation of Sultana and Sunmuscat under the conditions those varieties are grown under in Australia, and thereby enable the initiation of drying process sooner.

Trial 2 - Emulsion strength

Concern regarding the efficacy of the emulsion strength being used for trellis drying, and the wisdom of applying a second spray were raised as part of on-going discussion regarding achieving rapid drying down to 16% moisture and minimising inputs. The former was probably the greater driver because the Sunraysia region experiences adverse drying conditions in two seasons of every five. Rapid early drying is, therefore, critical.

There was also recognition that the current recommendations for emulsion strength were based on research on Sultana, which is generally cut for trellis drying in early to mid-February. It is not known whether those recommendations are entirely appropriate for Sunmuscat, particularly given that initial drying conditions for Sultana are usually more favourable than the initial drying conditions for Sunmuscat; a later maturing variety that may not be cut until late February-early March. Achieving rapid initial drying for Sunmuscat is obviously quite critical to getting moisture levels down to 16% before overnight dews and cooler and more humid conditions prevail.

Emulsion strength is defined as the percentage oil (*i.e*. L/100L spray mix) and the percentage of potassium carbonate (*i.e*. kg K_2CO_3/100L spray mix).

The outcome of the discussions was the design, setup and conduct of trials to investigate the loss of moisture from Sultana and Sunmuscat grapes drying on the trellis as a function of emulsion strength and the number of applications of emulsion. The trials were not set up to test the effects of varying oil percentage versus varying K_2CO_3 percentage; the ratio of the concentrations of oil and K_2CO_3 were constant.

Trial 3 - Drying conditions

Trellis drying is now a well-established industry practice, but concerns linger about the impact of wet weather on drying fruit. Drying grape berries involves the movement of moisture from the interior of the berry to the berry surface, evaporation from the surface and movement of the resultant moisture vapour away from the surface and into the bulk atmosphere. These processes are driven by the maintenance of a strong vapour pressure gradient (*i.e.* low relative humidity versus high relative humidity). Warm weather helps drive that gradient. Bulk air movement into and out of vineyards is obviously an important factor, but when bulk air movement is low or negligible, the microclimate in and around the drying zone assumes great importance.

Some local wine grape and table grape producers modify vineyard air temperatures by applying small irrigations specifically to allow evaporative cooling from the soil surface. This suggests that it may be possible to modify the relative humidity and temperature It follows that the opposite effect may be possible (*i.e*. drier and warmer air). Management of the vineyard floor is important because of the soil's capacity to absorb and release heat, the evaporation of water from the soil surface and the transpiration of water by green ground cover plants.

Detailed knowledge of the relative humidity and temperature in the drying zone is qualitative at best. Such knowledge is needed to identify vineyard floor management practices that may alter drying conditions favourably.

Growers' practices

Widespread wet weather during drying do not result in all DVF delivered to processors being dark. At the very least this suggests that there may be a variety of drying practices, or variants of practices, being used, some of which result in lighter coloured DVF in seasons when weather conditions were such as to suggest that that outcome was unlikely. On that basis then, a survey of DVF producers drying practices was undertaken to help identify variants of practices that may be associated with better DVF colour.

Methodology

Full Literature Review

The terms of reference for the full literature review were drafted in July 2014 and finalised in consultation with Project Management Committee (PMC) members in August 2014. The PMC was keen to ensure that the literature review, along with the final report & recommendations arising from the Stage 1 project, together with industry advice, would help determine the content of the “Best Practice Guide” and decisions relating to any further on-farm trials. Refer copy attached

The PMC considered several potential candidates for this engagement and ultimately agreed that a recently retired DEPI researcher, Karl Sommer, should be approached to determine his interest in this project. Dried Fruits Australia subsequently consulted with Karl Sommer and agreement was reached on the terms of his engagement.

Dried Fruits Australia provided Karl Sommer with all relevant information on hand, including various research reports and published papers. Information provided included the earlier literature review undertaken during mid-2013, as well as the final report on the Stage 1 project (“Producing High Value Dried Grapes”).

Karl Sommer provided the PMC with a detailed briefing on Wednesday 29th October 2014. This resulted in a thorough discussion with PMC members about the major factors influencing quality light fruit production and where the continuing research focus should be.

The PMC met again on Friday 31 October 2014 and agreed on the approach required for the Stage 2 project going forward in 2014/15. The PMC agreed that further on-farm trials should be conducted in the areas of fruit maturity, drying emulsions & vineyard micro-climate.

The final literature review document was received from Karl Sommer on 17th December 2014.

Best Practice Guides

The PMC established a small expert working group to provide advice on the content and format of the Best Practice Guide. Working group members included Ivan Shaw (PMC Chairman) and John Hawtin (DFA Industry Development Officer).

DFA then engaged consultants, Jacinta & Terry Gange (News Alert PR) to coordinate the preparation of the Best Production Guide (BPG) in close consultation with the working group members and PMC. DFA had previously worked with the Ganges on a similar project – development of the Dried Grape Production Manual in 2005.

An early decision was made resulting in the BPG being prepared in several parts, rather than trying to prepare and finalise a single document. The main reason for this was the desire of the working group and PMC to get up to date information ready and distributed to dried grape growers prior to the commencement of the 2015 harvest in February.

The Best Practice Guide – Part 1 (Pre-harvest to harvest) was finalised and launched at a special DFA event on Friday 16th January 2015. Press and industry representatives were present.

The Best Practice Guide, Part 2 “Post-Harvest & Winter”, was finalised and launched in early April 2015. The final stage, Part 3 “Spring & Pre-harvest” was finalised in mid-late August 2015.

Importantly, the major dried fruit processors, Sunbeam Foods and Australian Premium Dried Fruits confirmed their commitment to this project and distributed over 500 copies of the BPG to their clients through special mailings.

On-farm trials

Trial 1 Advancing maturation with potassium (to assess the impact of potassium sprays on maturity of dried grape varieties of Sultana& Sunmuscat)

Trial 2 Drying emulsion rates to improve drying (to assess the impact of drying emulsion strength on the time needed to dry fruit to harvestable moisture content)

Trial 3 Improving drying conditions in the vineyard (to assess the impact of vineyard floor management on drying conditions in vineyards for the production of dried vine fruit)

These 3 trials were conducted during two consecutive harvest periods, in 2014/15 & 2015/16.

The 2015 season was ideal for fruit development with the result that fruit maturity was earlier than normal. The harvest period saw the best weather conditions for drying fruit that had been experienced for many years. While these conditions were ideal for dried vine fruit producers, they were not considered to be average weather conditions for a typical drying and harvest period – which meant that the rationale behind the field trials which sought to provide drying grapes with longer exposure to higher daytime temperatures and reduced exposure to adverse weather could not be fully tested.

As a result, HIA approved a project variation to enable the same field trials to be repeated in 2015/16 when an ‘average season’ was likely with drying interrupted by rain event(s) enabling the project objectives of maximising the exposure of drying grapes to higher day time temperatures for longer and minimising the exposure of the fruit to the vagaries of the weather, to be tested.

Unfortunately, from the research perspective, the 2015/16 season was not an “average season” but rather another season that provided excellent drying conditions, again preventing the rationale behind the field trials from being fully tested.

Trial 1 - Advancing maturity

Using the Sunraysia TAFE training farm at Koorlong, north west Victoria, as the experimental site, Albion Laboratories Inc.'s "Potassium-0-0-24" formulation (hereafter referred to as "K-metalosate") was applied twice to three whole rows of Sultana and two whole rows of Sunmuscat vines at a rate of 7L/Ha on each occasion. Three rows of unsprayed rows of vines were used as controls for the Sultanas and two unsprayed rows were used as controls for Sultan. The control rows were separated from the sprayed rows by two buffer rows. The application dates for each season are presented in Table 1.

Table 1 K-metalosate application dates and day of year (DoY) for Sultana and Sunmuscat on the Sunraysia TAFE Farm at Koorlong, north west Victoria, in each of two seasons

		Season			
		2014-15		2015-16	
Variety	Application	Date	DoY	Date	DoY
Sultana	1st	15 Feb	15	22 Jan	22
	2nd	17 Feb	17	5 Feb	36
Sunmuscat	1st	22 Feb	22	22 Feb	53
	2nd	25 Feb	25	29 Feb	60

Berries were sampled from each variety the day before the first spray application, and then approximately every 10 days after that application through to about 30 days after the initial application. Berries were sample from bunches along the row. Due to the favourable weather conditions this season, the last samples were collected after what would normally be considered a suitable maturity to harvest the grapes or initiate trellis drying.

At each sampling, two berries were sampled from the shoulders of each bunch, two from the middle and one from the tail. The berries were crushed gently in a plastic bag, mixed thoroughly and a few drops removed for determination of total refractable soluble solids (TSS) on a temperature compensated digital refractometer.

To estimate when °Brix reached an arbitrary point, the (*DoY*, *°Brix*) data points were subjected to regression analysis using a rational 3-parameter function described by:

$$°Brix = \frac{[1 + (a \times DoY)]}{[b + (c \times DoY)]}$$

where *a*, *b* and *c* are coefficients estimated by the regression algorithm. This procedure was conducted using MS-Excel's Data/Solver option.

Transposing that equation provides:

$$\mathrm{DoY} = \frac{[(b \times °Brix)\text{-}1]}{[a\text{-}(c \times °Brix)]}$$

Setting *°Brix* to an arbitrary target maturity (for example, 20) allows an estimate of the day of the year the target berry maturity was reached. Conducting that procedure for each replicate for each treatment for each variety for each year allows comparisons of the effectiveness of K-metalosate for each variety in each season, across seasons and across seasons and varieties.

Trial 2 - Improving the rate of drying

The physical layout of the treatments and the experimental design are set out in Figure 1. The rows ran east-west, and so the fruiting side of each row faced south or north.

The trials were conducted in both the 2014-15 and 2015-16 seasons, and emulsion application dates are listed in Table 2.

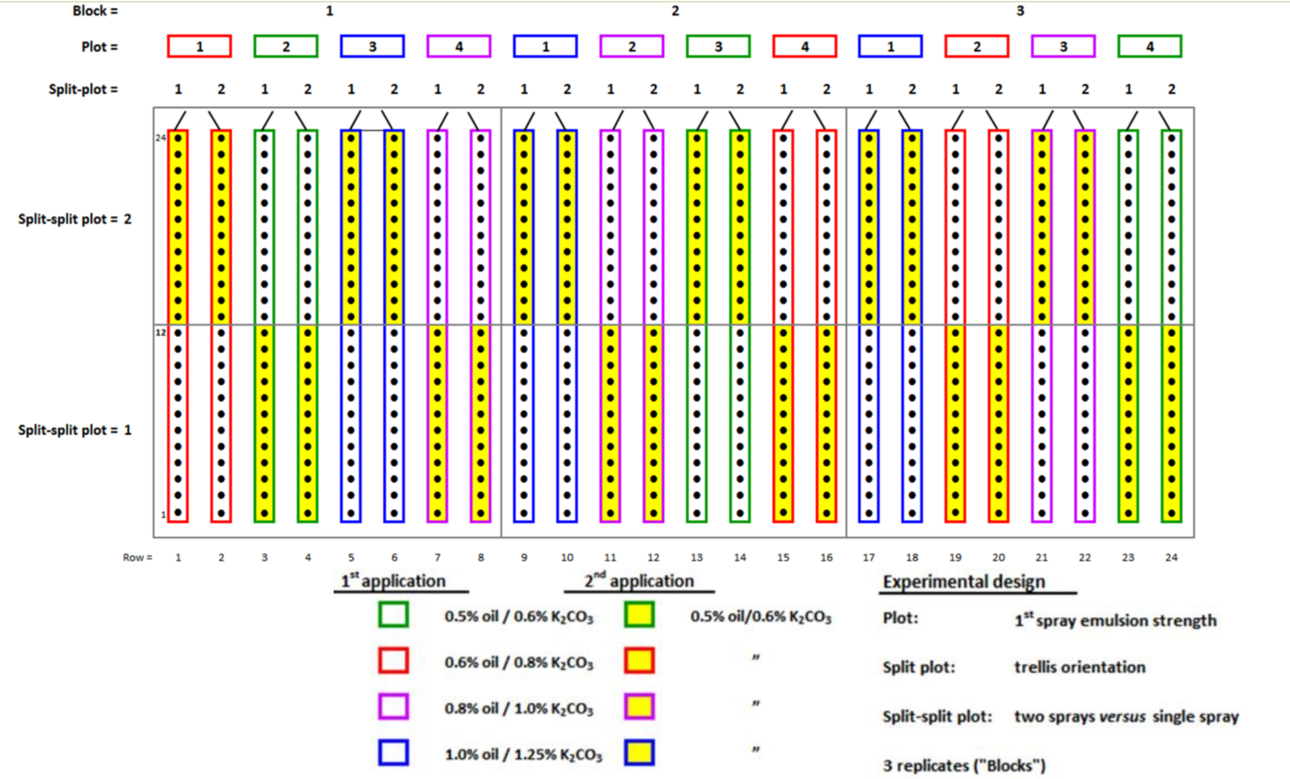


Figure 1 Plan of the Sultana and Sunmuscat emulsion strength trials conducted on Sunraysia TAFE's farm at Koorlong during the 2014-15 and 2015-16 seasons

Table 2 Emulsion application dates and day of year (DoY) for Sultana and Sunmuscat on the TAFE Farm at Koorlong, north west Victoria, in each of two seasons

		Season			
		2014-15		2015-16	
Variety	Application	Date	DoY	Date	DoY
Sultana	1st	17 Feb	48	13 Feb	44
	2nd	23 Feb	54	20 Feb	51
Sunmuscat	1st	18 Feb	49	22 Feb	53
	2nd	24 Feb	55	29 Feb	60

Grapes were sampled before the emulsion application and then every four days thereafter to determine the moisture content. Berries were collected from bunches down half rows, weighed and dried at 55°C for two weeks and re-weighed.

To estimate when each moisture content reached 15% curves were fitted to the moisture content data for each replicate for each treatment for each variety.

The relationship fitted was of the form:

$$\%\,moisture = min + \frac{(max - min)}{\left(1 + \left({DoY}/{a}\right)^{-b}\right)}\ ,$$

where *min* = minimum % moisture; *max* = maximum % moisture; DoY = day of year; a and b are coefficients estimated by the regression algorithm.

That equation was then transposed to yield:

$$DoY = a \times \left[\frac{(max - min)}{(\%moisture - min)} - 1\right]^{1/b}$$

Setting % moisture = 15% and using the estimates of min, max, a and b provided by the regression algorithm, an estimate of DoY can be made. This value represents the day of the year that moisture levels in that parcel of drying grapes reached 15%, which is 1% less than that needed to efficiently harvest dried grapes off the trellis. That, in turn, allowed an estimate of the number of days from wetting/cutting to being ready to harvest.

Trial 3 - Microclimates in vineyards during drying

The aim of this trial is to assess the impact of vineyard floor management on the temperature and relative humidity of the air in the vineyard during trellis drying as the basis for identifying conditions that will result in fruit drying more rapidly.

The plan had been to compare the air above three vineyard floor management strategies, namely:

- bare compact earth,
- mulched dry cover crop/volunteer weeds on vineyard floor and
- green standing cover crop.

Thirty rows of Sunmuscat vines on swing arm trellis on the Sunraysia TAFE farm at Koorlong were used; 10 rows per treatment. Twenty inter-rows were sown with Rebound millet cover crop seed on in December of each season and irrigated immediately after sowing. The remaining nine inter-row areas were kept bare by cultivation. Growth of the millet cover crop was encouraged by the application of urea in January of both seasons.

A mis-communication in the first season resulted in all the cover cropped inter-row areas being slashed, and effectively reducing the trial to a single comparison of mulched vineyard floor surface versus a bare vineyard floor surface in that season. The full planned comparison occurred in the second season.

Temperature and relative humidity (RH) sensors (Tinytag TGP 4500[1]) in mini-Stevenson Screens were installed on a length of PVC pipe at 0.5, 1.1 m (in the fruiting zone) and 0.5 m above the trellis in the vine row. The sensors were installed a few weeks prior to cutting and spraying to check functionality. The sensors were removed just prior to cutting and wetting, and re-installed shortly thereafter. The air temperature and RH were recorded every 15 minutes.

[1] http://www.hdl.com.au/sites/hdlcomau/files/user/3/TGP-4500.pdf

Figure 2 Stevenson screens containing temperature and RH sensors installed in a summer-pruned swing arm trellis Sunmuscat vines on TAFE farm at Koorlong

The screens were 0.5 m above the vineyard floor, adjacent to drying fruit and 0.5 m above the canopy.

In the first season two sets of loggers were installed in each of the bare earth and mulched areas; one set in a row with the fruiting side facing north and the other in a row with the fruiting side facing south.

In the second season two sets of loggers were installed in each of the bare earth, mulched and cover cropped areas; one set in a row with the fruiting side facing north and the other in a row with the fruiting side facing south.

Growers' practices

A survey of dried vine fruit producers was conducted to try to identify on-farm management practices that on an empirical basis were more likely to result in light coloured DVF than dark DVF in the 2014-15 season.

The survey (included as Appendix 1) was sent to all DVF producers in May, 2015.

Outputs

Outputs from the stage 2 project included:

- a full literature review report entitled “Producing High Value Dried Grapes” being produced and made available to dried grape growers and Australian processor/marketers (refer Appendix 6)
- a three-part Best Practice Guide being produced and distributed to dried grape growers and Australian processor/marketers (refer Appendix 7)
- Detailed reports on the on-farm trials conducted in both the Stage 1 & Stage 2 projects
- A series of research updates published in The Vine magazine, circulated to all dried grape growers (refer Appendices 2-5)
- Research Update presentations at several industry forums during 2015 & 2016

The On-Farm Trials

Trial 1 - Advancing maturity

Spraying K-metalosate on Sultana or Sunmuscat vines did not affect the accumulation of total soluble solids by Sultana and Sunmuscat (Figure 3) in either season. The analysis of the data suggested that the only significant source of variation was time, and the application of K-metalosate did not alter those trends for either variety in either season.

The lack of industry-wide maturity data notwithstanding, maturation in the 2014-15 season was considered earlier than normal, and it was suspected that possibly this timing was too late for the material to have an effect. Applications were earlier in the second season (TSS between 10 and 15 ^{o}Brix), but no effect on the accumulation of TSS was apparent in either variety.

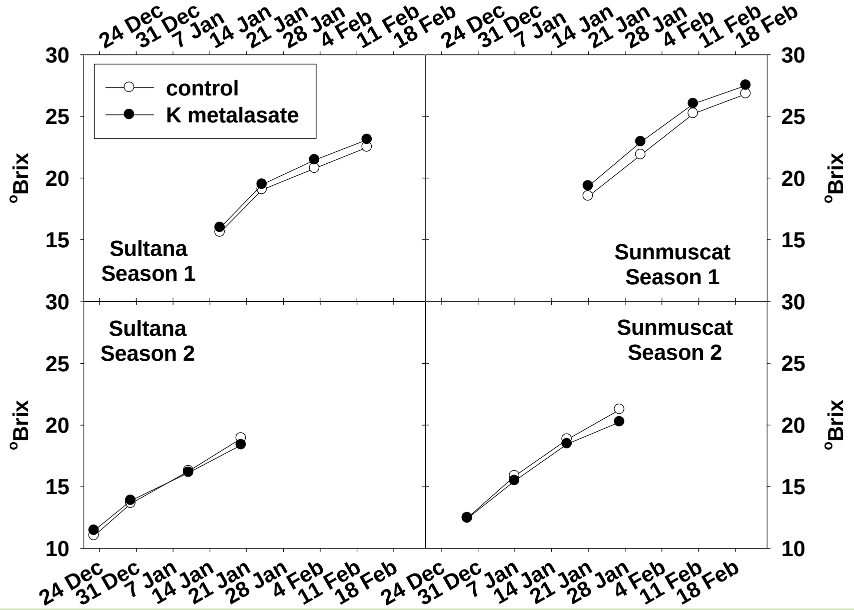
Analysis of the estimates of the day-of-the-year that 20 ^{o}Brix was reached supported the conclusion that the application of K-metalosate under the circumstances prevailing in the 2014-15 and 2015-16 seasons and the characteristics of the trial site did not accelerate the accumulation of TSS in either variety.

The trials also highlight an issue that field-based research frequently contends with; namely, the inherent variability within an ostensibly uniform management unit. Sufficient replication can overcome the difficulty imposed by such variability, but at a cost. If the exercise was to be repeated consideration should be given to applying the formulation using whole vines as the experimental unit; this would provide more opportunity for experimental replication, but would impose a logistical cost associated with sampling, spray application and measurement.

The trial also highlighted the fact that the industry does not have any mechanism in place to monitor and record phenological development. Earlier knowledge of the state of maturity of these two varieties across the industry would be of value more generally in making harvesting decisions as well. If the exercise was to be repeated, detailed knowledge of the state of maturation of the trial site to be used should be available from veraison onward.

Lastly, the success of K sprays in some grape production areas around the world shouldn't automatically

Figure 3 Time course of soluble solids accumulation by Sultana and Sunmuscat grapes in each of two season and as affected by two applications of K-metalosate



result in the conclusion that K sprays in other parts of the world will also be effective. It is possible that the region in which K sprays were shown to be beneficial may have some underlying K deficiency not previously recognised. Peacock and Smilanick's 2010 report to the Californian Raisin Board[2] also presented vine nutrient status data as point of reference to assess whether K sprays were addressing a shortfall in vine K during maturation. It is important here to acknowledge that the interpretative standards for petiole mineral nutrients at flowering were developed in reference to grape yields, and that maturation is only a component of yield, not the major determinant. A closer point of reference is needed, and, indeed, Peacock and Smilanick presented vine nutrient status data for both flowering (*i.e.* the industry standard sampling time) and veraison; the latter being much closer to the maturation than the former. Similar data would be advantageous on the Australian context to determine whether vine K levels were sufficient to explain the lack of response seen here. Such data would also be useful assessing vineyard K fertiliser practices in general.

Trial 2 - Improving the rate of drying

In both seasons the weather was ideal for drying grapes; between the first and second emulsion applications high temperatures during the day and overnight as well as very low relative humidities, resulting in a very rapid breakdown of the berries. This is illustrated by the estimates of moisture in the drying berries of both varieties during the 2015-16 season as affected by the strength of the emulsion applied to initiate the drying process (main panels in Figure 4 and Figure 5). Similar trends were observed for the 2014-15 season (data not presented).

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[2] Peacock, W.L. and Smilanick, J.L. 2010. Advancing maturity of raisin cultivars using potassium sprays applied to fruit. California Raisin Marketing Board - Annual Report for 2009 Research

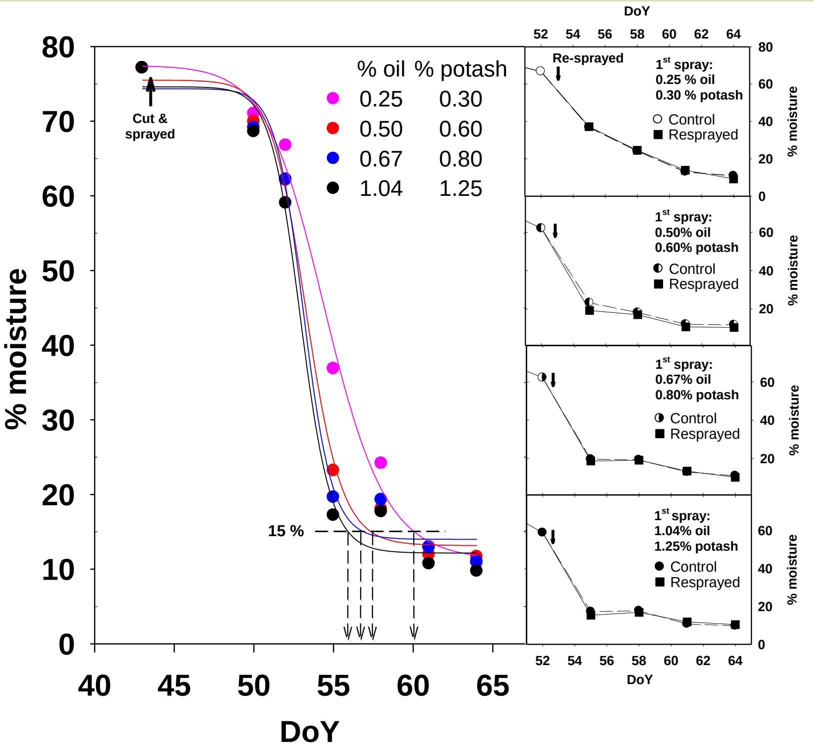


Figure 4 Sultana berry moisture following cutting and spraying with different strength emulsions (main graph, left) and the effect respraying with 0.5% oil/0.6% potash on Sultana berry moisture at different 1st spray emulsion strengths (right)

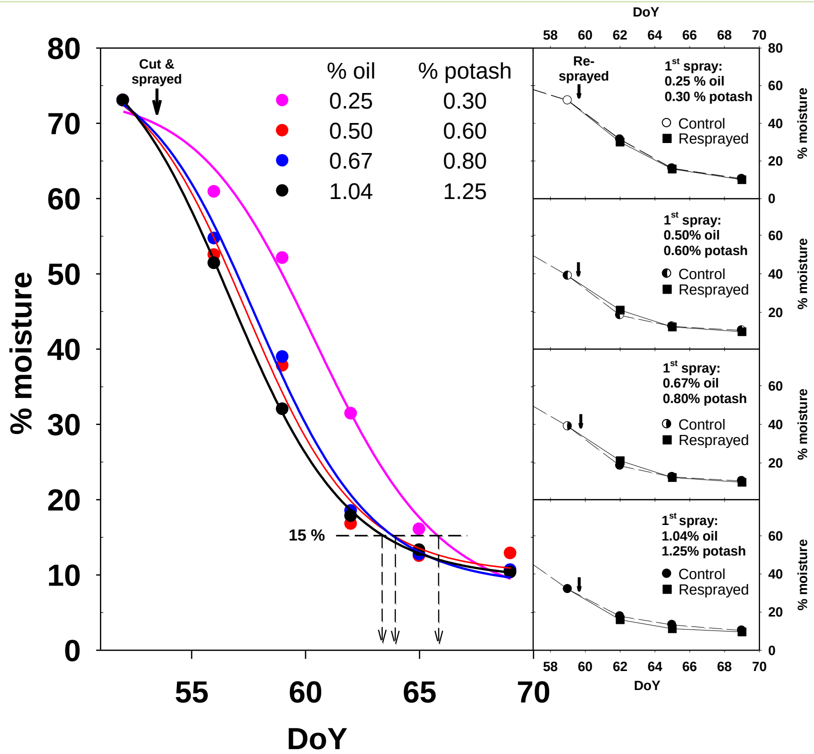


Figure 5 Sunmuscat berry moisture following cutting and spraying with different strength emulsions (main graph, left) and the effect respraying with 0.5% oil/0.6% potash on Sunmuscat berry moisture at different 1st spray emulsion strengths (right)

For both varieties for both seasons, emulsion strength was a significant source of variation in moisture levels during drying. The major effect was apparent between the lowest emulsion strength and the three higher strengths. In other words, there was no advantage applying an emulsion stronger than 0.5% oil/0.6% potash.

The effects of a second spray applied to drying grapes of each variety are also presented in Figure 4 and Figure 5. By the time the second spray was applied both the Sultana and the Sunmuscat berries had lost about a third or more of the water present in the berries when the vines were summer pruned and the first emulsion was applied. The application of a second spray to drying grapes of either variety in either season did not appear to accelerate drying.

Trellis aspect (*i.e*. whether the fruiting side faces south or north) is frequently cited as an important influence on the rate of drying. No evidence to support this notion was found. Under the drying conditions experienced in both seasons, whether the grapes had grown on the north facing side or on the south facing side had no impact on the rate of drying.

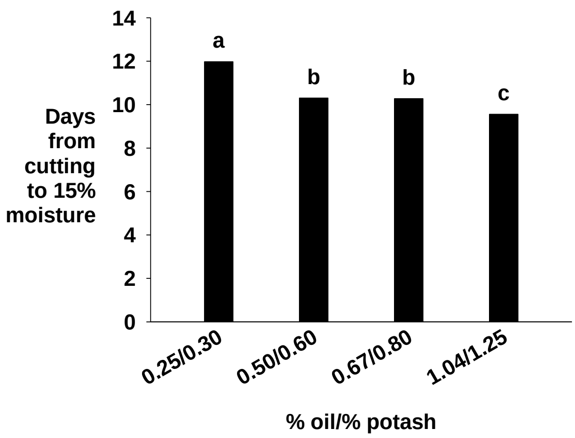
The aim of applying the drying emulsion is to dry grapes down to a moisture level that allows efficient harvesting. The estimates of day of the year that berry moisture levels reached 15% (which is 1% lower than the industry accepted standard of 16% for ideal harvesting) derived by interpolation allow an analysis of the impact of initial emulsion strength and the effect of a follow up spray. This process is figuratively represented by the vertical dashed lines on Figure 4 and Figure 5 where the horizontal lines drawn at 15% cross the regression curve for each emulsion strength. This process was conducted for each replicate for each treatment for each variety in each season. The estimates of the day of the year when 15% was reached was then subtracted from the day of the year when the drying process was initiated. The outcomes of the analyses of the days from cutting to 15% data across varieties and seasons and for each variety across seasons are presented in Figure 6 and **Figure 7**.

Across seasons and varieties, and irrespective of the strength of the initial emulsion applied, respraying with 0.5% oil/0.6% potash had no effect on drying. This supports the trends obvious in the left hand panels of Figure 4 and Figure 5.

Figure 6 Emulsion strength main effects on days to from cutting to 15% moisture

Values presented are means across seasons and varieties.

Different letters above columns indicate significant differences between means at P=0.05.

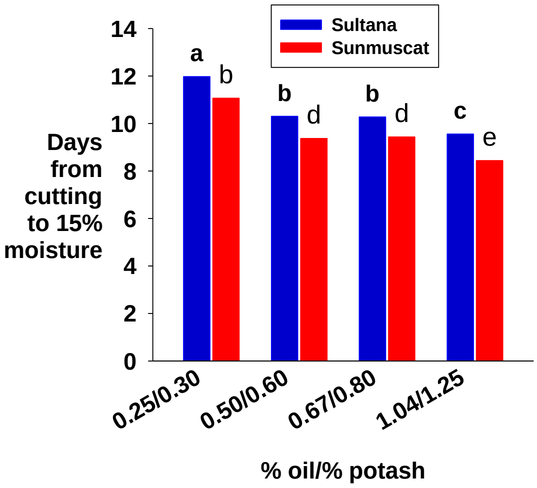


Across varieties and seasons the initial emulsion strength significantly affected the amount of time needed to dry grapes down to 15% moisture (Figure 6). Grapes that had been sprayed with 0.5% oil/0.6% potash or stronger were ready for harvest at least a day sooner than grapes that had been sprayed with the weakest emulsion. Grapes that had been sprayed with the strongest emulsion were ready for harvesting about two days sooner than grapes that had been sprayed with weakest emulsion and about a day sooner than grapes sprayed with the two middle strength emulsions.

A broadly similar picture emerges when the variety × emulsion strength interactions are considered (**Figure 7**). The nature of the significant interaction was that the same rate of moisture loss from Sunmuscat grapes as seen from Sultana grapes could be possibly be achieved with a weaker emulsion. This result is surprising given that although excellent drying conditions prevailed in both seasons, the conditions for Sunmuscat (the later maturing variety) drying were undoubtedly cooler than conditions for Sultana drying.

Figure 7 Interactive effects of variety × initial emulsion strength on days from cutting to 15% moisture

Values presented are means across two seasons. Within varieties different letters above columns indicate significant (P=0.05) differences between means.



As stated previously, these two season were the best drying seasons for many years, and, therefore, not ideal to identify better ways to dry grapes under sub-optimal drying conditions, which is the circumstance the industry has to contend with two seasons out of every five. An improvement of a day is significant in terms of avoiding predicted wet weather. Emulsion strength clearly reduced the time period between the initiation of drying and the fruit being ready for mechanical harvest. Of significance too is the raising of the possibility that Sunmuscat does not require quite as strong an emulsion to dry at the same rate that Sultana dried. Stated another way, using the same strength emulsion as used for Sultana (*i.e.* 0.5% oil/0.6% potash) may help overcome the disadvantage that Sunmuscats late maturity confers relative to Sultana.

Trial 3 - Vineyard floor management and air temperature and relative humidity during drying

Traces of the air temperature and relative humidity in a summer pruned Sunmuscat vineyard with swing-arm trellis as affected by vineyard floor management for the 2014-15 season and the 2015-16 season are presented in Figure 8 and Figure 9, respectively. There are some indications of some differences in the temperature and or the relative humidity between the air above the canopy, the air in the canopy and the air below canopy om some days and at particular parts of the diurnal cycles.

But, data as presented highlight the difficulty of interpreting data of this type; there are many measurements, differences are usually quite subtle and possibly highly transient. Two different approaches were used to help that interpretation.

The first approach treated the data for each height for each vineyard floor management as a "population". The statistics that described that population were then used to draw inferences about the effect of vineyard floor management on the temperature and relative humidity gradients in the summer pruned swing arm trellised Sunmuscat vineyard. Boxplots of the data for each season are presented in Figure 11 and Figure 14. The spreads and averages and of the temperature and relative humidity data collected during the 2014-15 dry season (Figure 11) suggest very little difference due either to the height the measurements were collected or the way the vineyard floor was managed. The spreads of temperature and relative humidity were also similar.

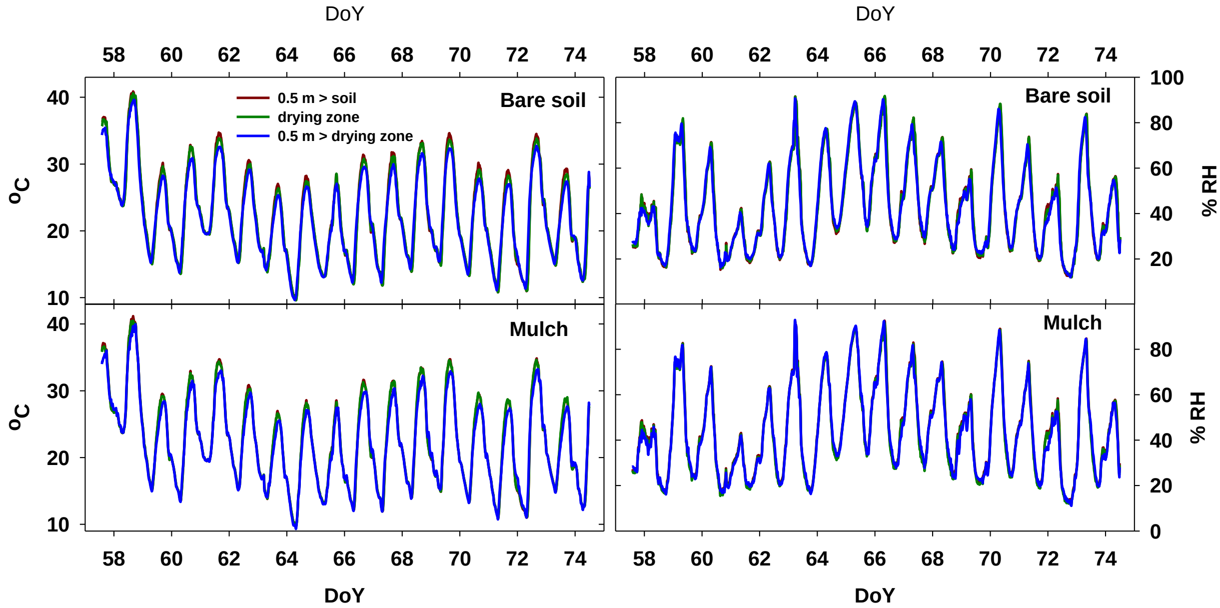


Figure 8 Traces of the temperature (left hand panels) and relative humidity (right hand panels) of air 0,.5 m above the soil, in the drying zone and 0.5 m above the canopy of trellis dried Sunmuscat vineyard as affected by vineyard floor management during the 2014-15 season

The Box plots for the data collected during the 2015-16 season suggest other factors were affecting the air temperature and relative humidity of the air above the vineyard floor (Figure 14). The factor or factors appeared to affect the vertical relative humidity profile more than the vertical temperature profile. The average relative humidity in the air above soil generally tended to decrease with height, but vertical profile was less marked above the bare soil compared to either the mulch or the permanent cover crop. Irrespective of measuring point, the air, on average, was warmer above bare soil compared to either mulch or cover crop. The highest temperatures were also higher for the bare soil treatment compared to either the mulch or cover crop treatments. The average air temperature in and below the drying zone appeared to be lower than the air temperature above the canopy.

Air pressure is a function of temperature and relative humidity, and differences in air pressure drive air movement. To help identify the nature and extent of any differences in temperature and relative humidity as a function of how the vineyard floor was managed, the second approach employed the differentials between the temperature and RH of the air above the soil and the air above the canopy because the Box plots suggested that there was a greater gradient between the lowest and the highest measuring points compared to between the either the middle and the highest or the middle and the lowest. A negative temperature differential means that the air soil is warmer than the bulk air, and a positive temperature differential means that the air above the soil is cooler than the bulk air. Similarly, a negative RH differential means that the air above the soil is wetter than the bulk air, and a positive RH differential means the air soil is drier than the bulk air. Further, the frequencies of positive and negative differentials were calculated to determine whether the air below the canopy was predominantly cooler and/or wetter than the air above the copy, which was assumed to represent the bulk air.

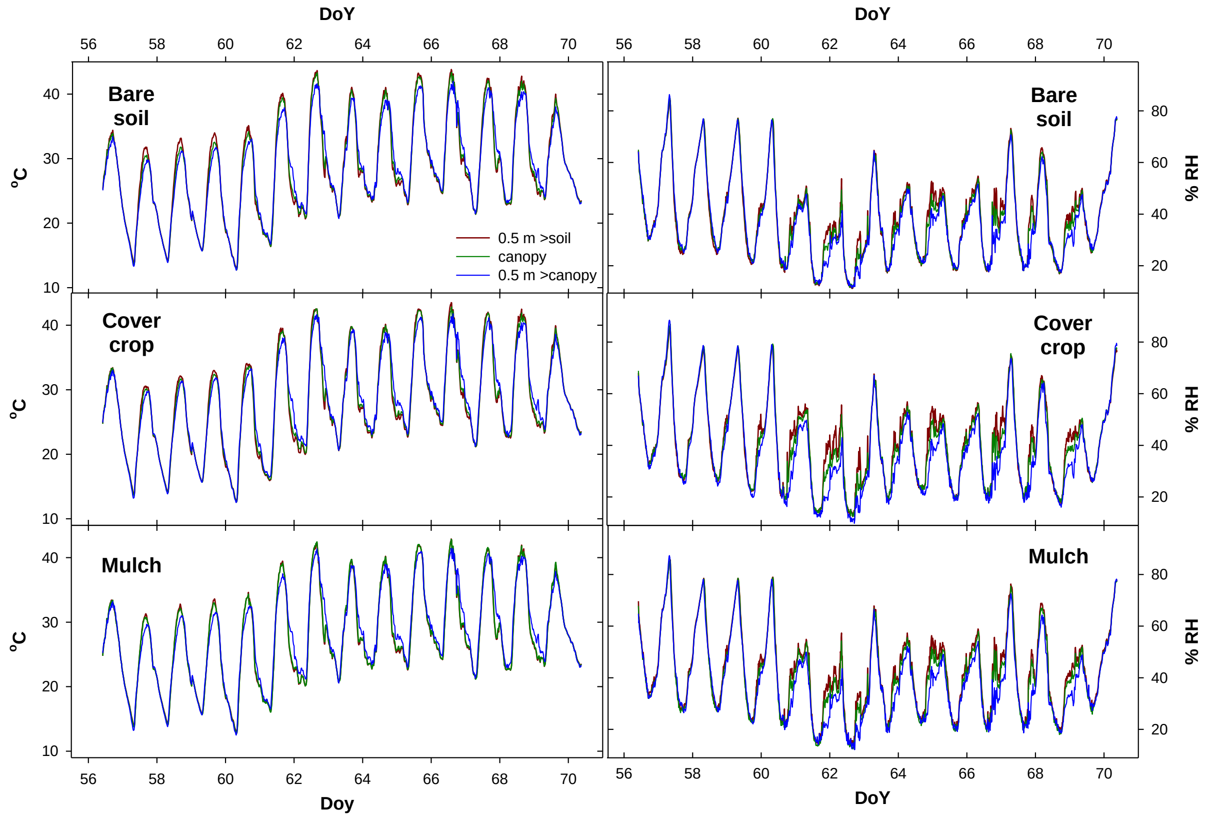


Figure 9 Traces of the temperature (left hand panels) and relative humidity (right hand panels) of air 0,.5 m above the soil, in the drying zone and 0.5 m above the canopy of trellis dried Sunmuscat vineyard as affected by vineyard floor management during the 2015-16 season

The results of those calculations are presented in Figure 12 and Figure 13.

The temperature and relative humidity differentials for the 2014-15 season (Figure 12) suggest that the air below the drying zone was more often warmer (by up to 2^{o}C) and moister (by up to 15%) than the bulk air above the canopy. In the mulch treatment, however, the air below the drying zone was cooler than the bulk air and moister than the bulk air for about two-thirds of the time.

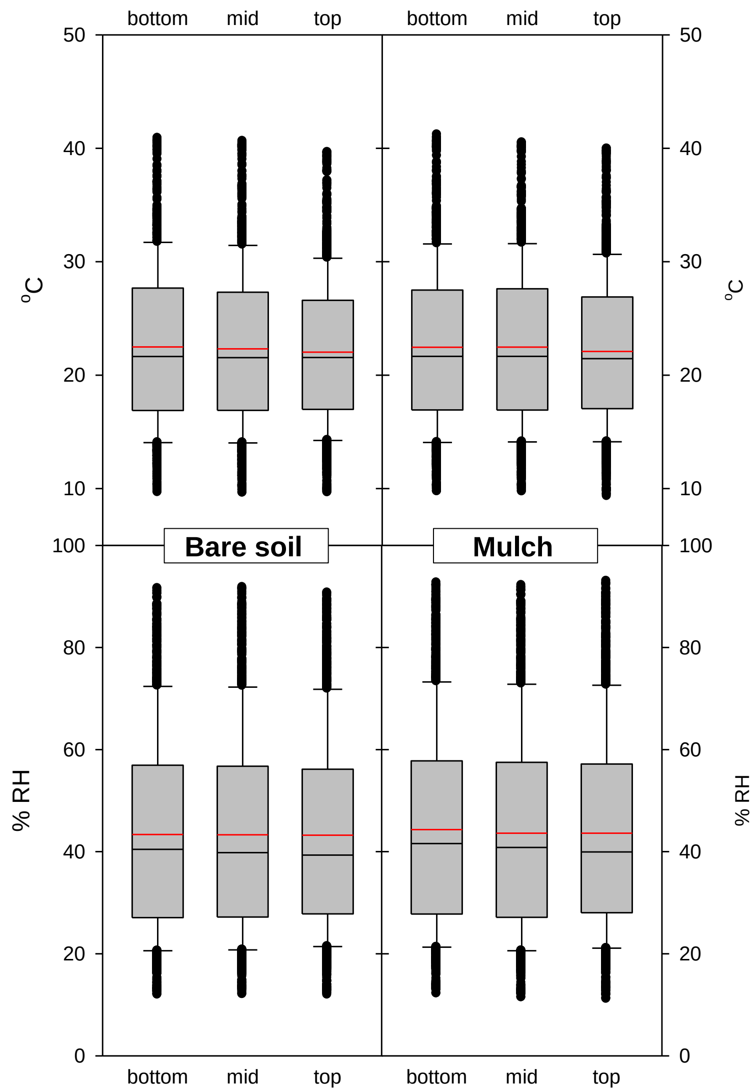
The temperature and relative humidity differentials for the 2015-16 drying season (Figure 13) suggested a more or less even spread of temperature differentials for the bare soil and the cover crop treatments, but the mulch treatment's differentials were predominantly leaning toward the air below the drying zone being warmer than the bulk air.

Further, because temperature and RH appear to be more-or-less inversely related (*i.e*. the air at the hottest part of the day is the driest, and the moistest air is usually observed when the air is coldest), plots of the temperature differentials versus RH for each time point should reveal when the air adjacent to the drying fruit is cooler and wetter, cooler and drier, warmer and wetter or warmer and drier relative to the bulk air. The air below the drying zone was predominantly wetter in all three vineyard floor treatments, but especially so in the mulch treatment. That differential was up to 25% in those two treatments. The differential in the bare soil treatment was relatively minor.

These measurements indicate that there are temperature and relative humidity gradients in a summer pruned Sunmuscat vineyard. The inference being that those gradients would drive air movement and hence move moist air away the surface of drying grapes. Two issues need to be pointed out here. Firstly, we can only infer that these gradients result in air movement; we have no direct measurements of air movement. Secondly, we do not know whether the gradients measured, and hence the vineyard floor management treatments imposed, have any impact on the rate of drying. It may well be that the movement of bulk air into and out of the vineyard is sufficient to overcome any build-up of moisture around the drying grapes. To answer both questions will require a more structured trial to assess fruit drying rates, and more sophisticated measuring equipment, particularly because when there is very little wind, air flow rates are low, and difficult and expensive to measure. The normal anemometers used to measure wind speed are not suitable for such circumstances.

Figure 10 Box plots of the temperature and relative humidity in a swing arm trellised Sunmuscat vineyard for 17 days following summer pruning in February, 2015.

50% of the observations fall in each box and the lower and upper vertical lines represent the lower and upper 25% of productivity observations. The black and red horizontal lines represent the median and mean values, respectively, and the black dots beyond the upper and lower whiskers represent outliers.



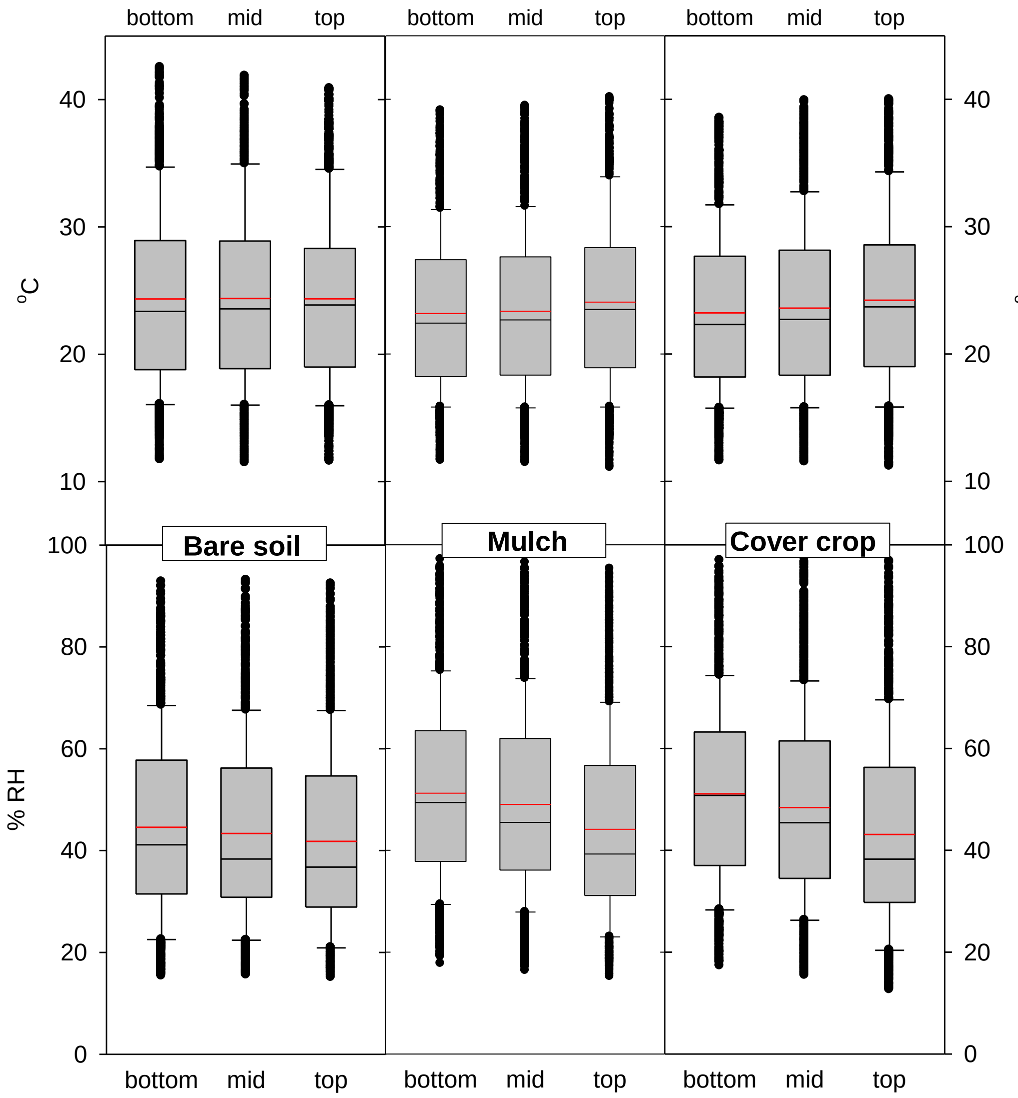


Figure 11 Box plots of the temperature and relative humidity in a swing arm trellised Sunmuscat vine for 24 days following summer pruning in February, 2016

50% of the observations fall in each box and the lower and upper vertical lines represent the lower and upper 25% of productivity observations. The black and red horizontal lines represent the median and mean values, respectively, and the black dots beyond the upper and lower whiskers represent outliers.

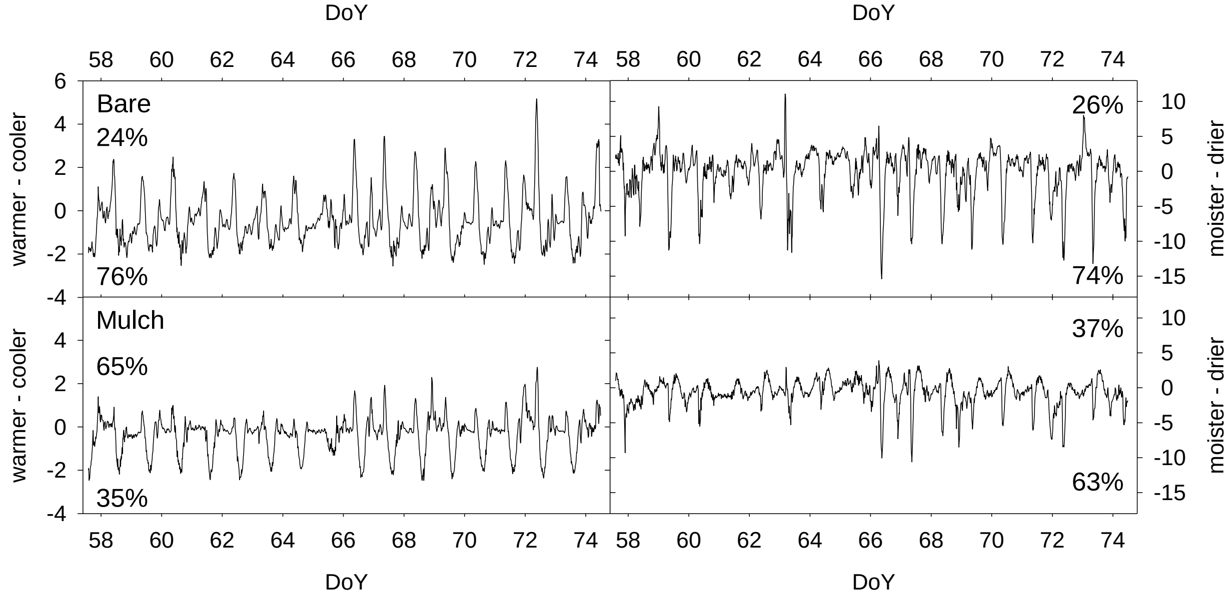


Figure 12 Temperature and relative humidity differences between the air above canopy compared to the air above the soil but below the drying zone for in a swing arm trellised Sunmuscat vineyard for 17 days following summer pruning in February, 2015

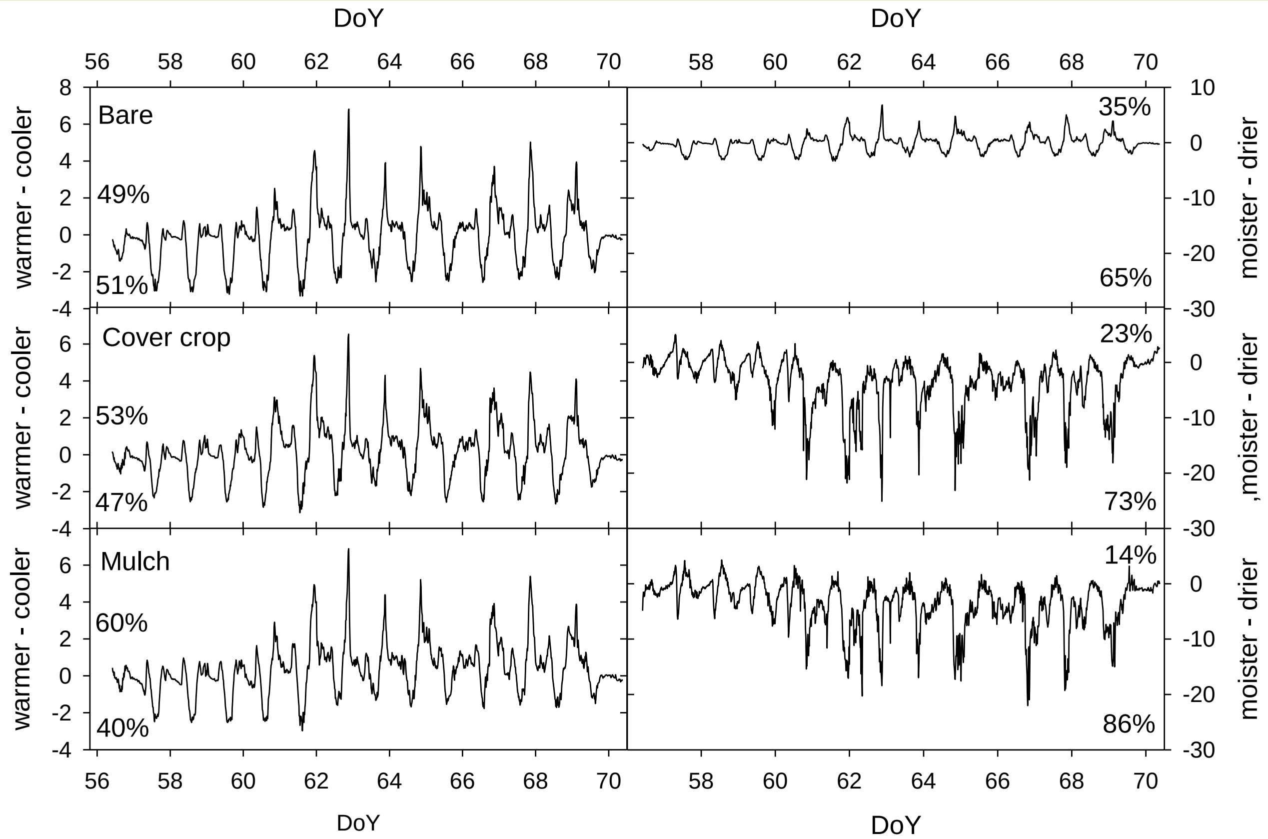


Figure 13 Temperature and relative humidity differences between the air above canopy compared to the air above the soil but below the drying zone for in a swing arm trellised Sunmuscat vineyard for 24 days following summer pruning in February, 2015

Growers' practices

Coverage

Fifty eight completed surveys were returned (Table 3); approximately 80% of deliveries were Sultana and Sunmuscat.

Total DVF production over the 2013-14 and 2014-15 seasons amounted to approximately 17 Kt/season.

Responses to questions on production practices for Sultana and Sunmuscat covered about 10% of the total tonnages delivered of each variety. Only summaries relating to those two main drying varieties are reported here.

Table 3 Total DVF deliveries and DVF production covered by responses

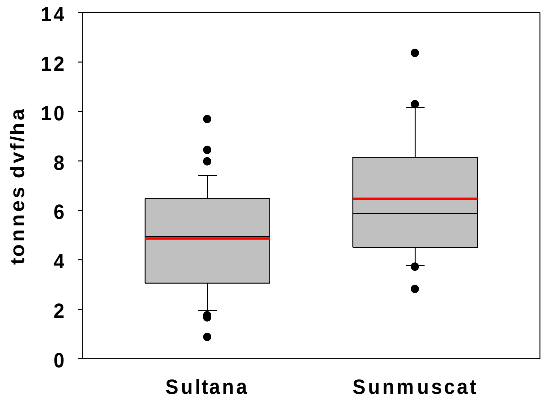
	t DVF described in surveys received
Sultana	1568
Sunmuscat	485
Sunglo	22
Raisin	234
Natural sultana	41
Currant	209
Total t DVF	2559

Productivity

Box plots describing the spread of productivity reported for Sultana and Sunmuscat are presented in Figure 14

Figure 14 Box plots describing population spread of Sultana and Sunmuscat DVF productivity.

50% of the observations fall in each box and the lower and upper vertical lines represent the lower and upper 25% of productivity observations. The black and red horizontal lines represent the median and mean values, respectively, and the black dots beyond the upper and lower whiskers represent outliers.



Sultana productivity ranged from around 2 to 7 t/ha, and Sunmuscat productivity ranged from about 4 to 10 t/ha. Mean productivities were approximately 5 and 6 t/ha, for each variety. Clearly, based on a single season's observations, there is a wide spread in productivity, and, therefore, significant room to improve overall producers' returns by addressing those issues that limit productivity at the lower end of the productivity scale. But, the survey did not seek information regarding production practices, and the productivity stability from season to season would need to be established to confidently attribute particularly levels of productivity with particular practices.

Rack versus *trellis drying*

Trellis drying accounts for well over two-thirds of all DVF delivered (Figure 15). But, approximately 75% of the fruit dried on racks was classified as light, compared to slightly more than half for DVF dried on the trellis (Figure 16).

Figure 15 Pie chart representing proportions of DVF produced by exclusively drying on the vine, exclusively drying on a rack, or using a combination of trellis and rack drying in their operations.

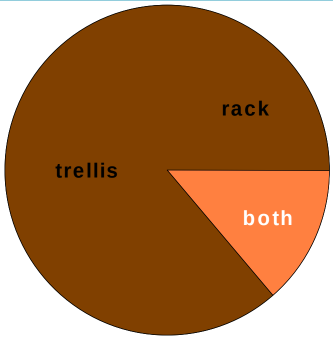
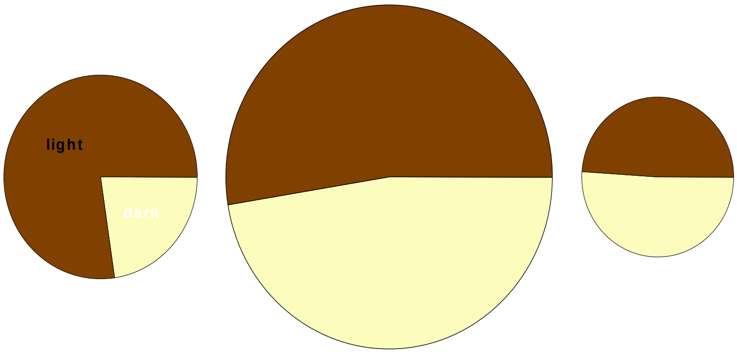


Figure 16 Pie charts representing the proportions of the total DVF delivered by each respondent classified as either light or dark and exclusively dried on a rack (left), dried on the trellis (centre) or dried using either method (right).

Note: pie chart areas reflect relative tonnages of fruit dried by each method.

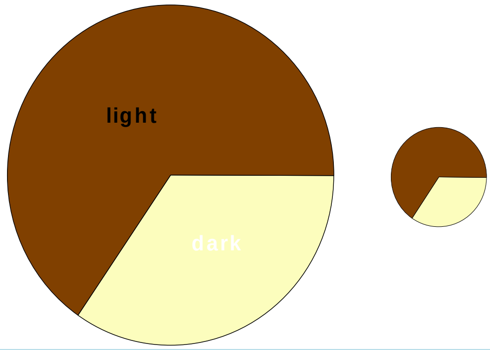


Approximately the same proportions of Sultana and Sunmuscat DVF were classified as light (Figure 17), but 100% of the Sunmuscat DVF produced by the respondents was trellis dried compared to 60% for Sultana.

The remainder of this section will be based on those respondents who trellis dried fruit exclusively because the majority of DVF delivered were dried on the trellis, and this method of drying is widely acknowledged as the most profitable way to produce DVF.

Figure 17 Pie charts representing proportions of Sultana (left) and Sunmuscat (right) DVF classified as light or dark upon delivery.

Note: pie chart areas reflect tonnages of DVF of each variety reported by respondents.



Emulsion applied

Three-quarters of the respondents trellis drying Sultanas reported using the recommended rate of 0.5% dipping oil and 0.6 % potassium carbonate (K_2CO_3), but only about half the respondents who reported trellis drying Sunmuscats reported using recommended rates (Table 4) The tendency amongst those trellis drying fruit and not using recommended rates was to use higher rates, and the tendency was stronger amongst those drying Sunmuscat compared to those drying Sultana.

Table 4 Percent of respondents producing dried Sultanas and/or dried Sunmuscat grapes using particular concentrations of oil and potassium carbonate (K_2CO_3) in the first drying emulsion applied to drying emulsion

Bolded numbers indicate "label rates".

		% (L *or* kg per 100L)														
		<0.3	0.3	0.4	**0.5**	**0.6**	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
Sultana	Oil	0	0	4	75	7	0	11	4	0	0	0	0	0	0	0
	K_2CO	0	0	0	7	75	0	4	0	4	0	4	0	0	0	7
Sun-muscat	Oil	0	5	10	40	5	10	25	5	0	0	0	0	0	0	0
	K_2CO	0	0	0	10	50	0	10	10	10	0	0	0	0	0	10

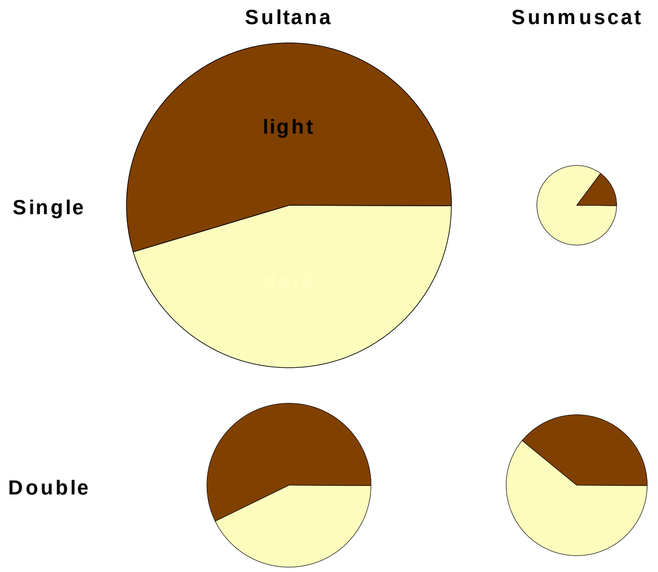
Across the board, two-thirds of respondents applied a 2nd spray, and all reported using the recommended rate of oil and potassium carbonate. The survey did not seek to identify the reason why a second spray was applied; clearly, though, ensuring complete coverage and/or hastening the initial breakdown rate would be the basis for applying a second spray.

However, no inference can be drawn regarding the effectiveness of the second spray application because, across the board, insufficient respondents reported the date of harvest.

Spraying Sultanas twice appeared to confer no advantage in terms of whether the fruit would end up graded light or dark (Figure 18). On the other hand, spraying Sunmuscats twice appeared to be associated with a lower proportion of DVF deliveries graded as dark. Possibly this reflects the fact that Sunmuscat is cut later than Sultana, and any acceleration of the initial drying by a second spray is reflected in a decreased likelihood of being affected by overnight dews *etc*.

Figure 18 Drying grade outcomes for single and double sprayed Sultana and Sunmuscat grapes

Note: pie sizes reflect tonnages relative to single sprayed Sultanas.



Summary

The data provided by the respondents quantifies a widely held view that adoption of trellis drying has been widespread, and dispels the notion that light coloured dried fruit is only produced on drying racks. Grapes dried on racks was slightly more likely to be classified as light, but not exclusively so. In other words, there are some practices or circumstances associated with trellis drying that may lead to darker DVF, and identifying these practices or circumstances may lead to better DVF quality outcomes for producers using this method of drying fruit.

The range of productivity reported suggests that many respondents are unaware of or are not applying existing knowledge of agronomic measures that enhance productivity. The range of productivity suggests that improving yields of the poorer producing enterprises is more likely to lead to substantial improvements in growers' returns than improving the proportion of light coloured versus dark coloured fruit given current price differentials.

The survey suggests that 75% of respondents drying Sultanas are applying drying emulsion at label rates, a small proportion are applying weaker rates and the remainder stronger rates. There was a wider spread of emulsion strengths being used by Sunmuscat producers. Use of a second spray appeared to confer no advantage in terms of Sultana DVF colour, but there is a suggestion that Sunmuscat was more likely to end up lighter coloured if they had been sprayed twice. Perhaps this is related to the fact that Sunmuscat matures later, and a second spray reduces drying time and hence the likelihood of exposure to dews as March. The spread in emulsion strengths being used by Sunmuscat producers suggests some dissatisfaction with the drying process using label rates.

Outcomes

As explained in the summary to this report, the main goal of this project was to develop best practice management information for use by growers, enabling the Australian dried grape industry to consistently produce high quality, light-coloured Dried Vine Fruit (DVF).

Specifically, through the 3 project activities, the project sought to achieve the following objectives:

- To build on a previous literature review entitled "The Influence of Vineyard Factors On The Colour Of Dried Vine Fruit At The Farmgate" by undertaking a full literature review to capture additional information from a range of industry sources, publications, published papers, project reports and direct feedback from industry and identify knowledge gaps and changes that need to be made to current management practices.
- To use information from the full literature review and final report of the stage 1project, to produce an updated Best Practice Guide which provides growers with clear recommendations for the consistent production of high quality, light DVF.
- To develop improved trellis drying management systems for adoption by growers that improve the likelihood of producing quality, light coloured fruit by maximising the exposure of drying grapes to higher day time temperatures for longer and minimising the exposure of the fruit to the vagaries of the weather during the drying process. This involved three on-farm trials being conducted:
  a) Trial 1 - Advancing maturation with potassium (to assess the impact of potassium sprays on maturity of dried grape varieties of Sultana& Sunmuscat)
  b) Trial 2 - Drying emulsion rates to improve drying (to assess the impact of drying emulsion strength on the time needed to dry fruit to harvestable moisture content, particularly the later maturing Sunmuscat)
  c) Trial 3 - Improving drying conditions in the vineyard (to assess the impact of vineyard floor management on drying conditions in vineyards for the production of dried vine fruit)

Outcomes achieved from project activities

The full literature review was completed and provided DFA and the Australian industry with an excellent summary of factors influencing the production of high quality dried grapes in Australia. This document has provided both growers and processors with an important reference document that includes all relevant research and industry information. The literature review document has been made available to growers and processors through the DFA's on-line knowledge management system.

A three-part Best Practice Guide was prepared using relevant information from the stage 1 project (Producing High Value Dried Grapes), the full literature review and feedback from industry stakeholders. The three-part Best Practice Guide (Part 1 Pre-harvest & Harvest; Part 2 Post-harvest & Winter; Spring to Pre-harvest) was printed and circulated to all dried grape growers through the major processors and directly by DFA.

The 3 field trials were completed in 2014/15 and repeated again in 2015/16, providing the industry with useful information relating to use of potassium sprays to advance maturity of Sultana & Sunmuscat, drying emulsion rates to improve drying and factors affecting drying conditions in the vineyard. As explained later, in the Evaluation and Discussion section, the potential benefits from these field trials were limited significantly by the excellent drying conditions experienced on both drying seasons.

Evaluation and Discussion

Literature Review and Best Practice Guide

These two project activities achieved the desired outputs and outcomes originally sought. The industry has been provided with a range of excellent reference documents, including a full literature review which includes all relevant research and industry information on factors impacting the production of high quality light fruit in Australia, as well as three-part Best Practice Guide that summarises a lot of information and presents it in an easy to use document. The strong feedback from growers and processors confirms that these documents have been found to be extremely useful.

The evidence is fairly strong that these project activities have produced outputs of great use to the industry and have already seen beneficial outcomes in the form of better management practices leading to improved quality of dried grape production. While this improvement has been influenced by good drying conditions during the past 2 seasons, grower use and processor promotion of the Best Practice Guides has undoubtedly had an impact as well.

On-farm Trials - Overall summary and conclusions

The 2014-2015 and 2015-16 seasons were the best for many years; advanced maturity and no adverse weather. The objective of the trials conducted was to provide DVF producers with risk management options to cope with adverse drying conditions, such as wet weather at the outset or during the drying process. Getting drying fruit to 16% moisture a day sooner was seen as a significant advantage in terms of avoiding autumn dews and wet weather in general.

The first element in this approach was to investigate the use of potassium sprays to advance maturity based on Californian research showing the application of a particular formulation advanced maturity by 7-10 days. An advancement of maturation of that scale would be a great advantage for Australian DVF producers. However, the Californian research results were not replicated in the trial conducted as part of this project. On one level it suggests that the edaphic circumstances of the Californian experiments, and the Californian industry in general, are different to the edaphic circumstances of the Australian DVF industry, particularly with respect to soil fertility; in this case potassium. On another level, this result underscores the wisdom of exercising caution when considering practices developed in other production regions. Possibly one explanation for the lack of a maturity response lies in the fact that potassium inputs in the spray emulsion amounts to around 30 kg per ha per season[3]. Some of this amount would have remained on the grapes when sprayed, but a large proportion would be retained on the foliage and shoots, which eventually find its way on to the soil surface.

The second element in the approach was to investigate the impact of emulsion strength on drying rates. Using emulsions of different strength but constant emulsified oil and the potassium carbonate ratio it could be shown that stronger emulsions resulted in DVF reaching 15% moisture 1-2 days sooner than weaker emulsions. Given that it appears that the initial stages of drying are critical, but that industry experience suggests that fruit that are sprayed with stronger drying emulsions are more prone to adsorbing moisture if it rains or heavy dews are experienced, some caution is needed before suggesting stronger emulsions, particularly during seasons of delayed maturity. Applying a second spray had no effect on the number of days from cutting to attaining a harvestable moisture level.

[3] Industry experience suggest that approximately 10,000 L of emulsion is “consumed” per hectare; at the label rate of 0.6% potash (57% K), this amounts to around 34 kg of K/ha.

This component also provided evidence that Sunmuscat may not require the same strength emulsion as used for Sultana. Herein lays a conundrum: drying conditions are generally less favourable when DVF producers are trying to dry Sunmuscat compared to when they are trying to dry Sultana, and the temptation is to use stronger emulsion to take advantage of whatever dry/warm weather is available. But, stronger emulsions are more likely to result in darker fruit as dews become more frequent in autumn. This conundrum adds weight to the case for advancing maturity to take advantage of warmer/drier weather, but coupling that with a weaker emulsion.

The third element in the approach was the physical environment surrounding drying fruit. The temperature and relative humidity—as influenced by vineyard floor management options— of air in the drying canopy was compared to the air above the drying canopy. The air adjacent to the drying grapes was more likely to be drier if the vineyard floor was bare compared to the vineyard floor being covered in a layer of mulch. But, irrespective of vineyard floor management, the air adjacent to the drying grapes was more likely to be warmer than the bulk air. This is a complex field of research because of the dimensionality of the environment; the vertical and horizontal movement of air, the temperature and relative humidity of that air, all with a temporal component, make investigations into the drying environment a non-trivial matter. The data gathered to date suggests some differences attributable to vineyard's floor, but the importance of those differences are unknown. This is an area that does warrant attention because anything that can hasten drying, particularly during the initial stage, will confer an advantage to DVF producers.

The fourth element was a survey of practices used by DVF producers. As an aside, the survey highlighted the wide disparity in productivity levels across the industry. Given that the all the fixed costs and most of the variable costs of production would be more or less the same irrespective of whether productivity was 2 t DFV/ha or 12 t DVF/ha, there would seem to be considerable scope to raise DVF producers' incomes by improving production practices generally.

That point aside, the survey provides some hard evidence to support the empirical observation of many in the industry that adoption of trellis drying across the industry is widespread. The use of trellis drying though may come at a cost however; DFV producers were more likely to produce dark DVF by drying the fruit on the trellis compared to drying fruit on the rack. But, the fact that not all fruit dried on the trellis dries dark suggests that other factors are at play. One such factor maybe the time that the canes were cut, and the difficulty of the limited number of harvesters available imposes on harvesting DVF in a timely fashion. That factor may therefore be exposure to moisture as dew or rain late in the season whilst waiting for a harvester to be available. Advancing maturity to avoid those circumstances would be advantageous to the industry if the production of light-type DVF is seen to be economically attractive.

The survey also suggested a high degree of compliance with label recommendations with respect to dry emulsion formulation; more so with Sultana producers compared to Sunmuscat producers. The latter point suggests some dissatisfaction with recommended formulation for Sunmuscat, possibly related to the perception that the initial stages of drying need to be accelerated to compensate for the later maturity. This perceived need being reflected in the fact that the majority of Sunmuscat producers applied a second spray, and that more of this fruit were classified light compared to fruit Sunmuscat that was only sprayed once. Proportionally, far fewer Sultana producers relied on a second spray, and the colour classification outcome was unrelated to the number of sprays applied in any case.

Recommendations

That consideration should be given to a more detailed look at drying micro climates with a focus on row spacing, trellis configuration and vineyard floor management. This could involve looking at the influence of air movement and drying rates with close rows and overhead pergola systems compared to standard or wider rows.

>

Scientific Refereed Publications

None to report

>

Intellectual Property/Commercialisation

No commercial IP generated' if there is none to report

Acknowledgements

Dried Fruits Australia acknowledges the assistance provided by Kevin Sharman (SuniTAFE farm manager), John Hawtin (DFA Industry Development Officer), Michael Case (Technical Officer) as well as Chairman (Ivan Shaw) and members of the Project Management Committee.

The assistance of Dr Michael Treeby in overseeing the on-farm trials component of this project and doing the data analysis and interpretation is gratefully acknowledged.

Appendices

Appendix 1	Grower Survey (May 2015). 10 pages
Appendices 2-5	Research Updates (Published in The Vine, Jan-Mar 2015; Apr-Jun 2015; Jan-Mar 2016; Jul-Sep 2016). 4 pages
Appendix 6	Literature Review (Producing High Value Dried Grapes). Copy of the cover, contents pages, conclusions and recommendations. 6 pages
Appendix 7	Best Practice Guide (3-part series) Part 1 (Pre-harvest to harvest); Part 2 (Post-harvest & winter); Part 3 (Pre-harvest & Spring). 1 page

2015 Post Harvest Survey

Name (optional)……………………………………………………………

How many tonnes of DVF of each grade did you produce?

Sultanas	*tonnes*	Sunmuscats	*tonnes*	Sunglo	*tonnes*	Currants	*tonnes*	Raisins	*tonnes*
5 Cr light		5 Cr light		5 Cr light		4 & 5 Cr		4&5 Cr Lex	
4 Cr light		4 Cr light		4 Cr light		3 Cr		4&5 Cr WX	
3 Cr light		3 Cr light		3 Cr light					
5 Cr brown		5 Cr brown		5 Cr brown					
4 Cr brown		4 Cr brown		4 Cr brown					
3 Cr brown		3 Cr brown		3 Cr brown					
Naturals									
Total tonnes		Total tonnes		Total tonnes		Total tonnes		Total tonnes	

Comments:………

……

Name of processor: ……………………………………………………………………………………

What was the tonnage per acre for each variety?

Sultanas	Sunmuscats	Sunglo	Currants	Raisins	Naturals

2015 Post Harvest Survey

Name (optional)……………………………………………………………

Was your property affected by hail?

	estimated % damage		estimated % damage
22 November 2014		**3 December 2014**	

How much damage do you estimate was incured from the early January rain event?

Sultanas	Sunmuscats	Sunglo	Currants	Raisins

What actions did you undertake to minimise splitting & mould?

Comments: ………

……

Did you water in the week prior to the January rain event?

Date	mm of irrigation

2015 Post Harvest Survey

Name (optional)…………………………………………………………….

What trellis are your vines grown on? ***Please tick***

	Tee Trellis
	Swingarm trellis
	Vertical hanging canes
	Other

Did you apply nitrogen fertilisers after December?

Fertiliser	Date of application	Method of application	Rate (Kg/ha)

How do you harvest and dry your fruit?

Hand pick & Rack dry		**If YES go to Q1**
Summer prune & Trellis dry		**If YES go to Q6**

2015 Post Harvest Survey

Name (optional)……………………………………………………………

Hand pick & rack dry section

1. What date did you commence & finish hand picking?

	Commence date	Finish date
Sultanas		
Sunmuscats		
Sunglo		
Carinas		
Raisins		

2. What rate of Drying Emulsion did you use for 1st spray?

	Oil (L/100L)	Potash (Kg/100L)	Caustic Potash	Volume per rack (L)
Sultanas				
Sunmuscats				
Sunglo				
Raisins				

3. What rate of Drying Emulsion did you use for the 2nd spray?

	Oil (L/100L)	Potash (Kg/100L)	Caustic Potash	Volume per rack (L)
Sultanas				
Sunmuscats				
Sunglo				
Raisins				

Name (optional)………………………………………………………………

4. How long did the fruit take to dry on racks? (days)

Sultanas							
Sunmuscats							
Sunglo							
Carinas							
Raisins							

5. What was your method to finish dry the fruit?

	Dry off racks	Ground dry	Bin Dehydrate
Sultanas			
Sunmuscats			
Sunglo			
Carinas			
Raisins			

If you did not summer prune & trellis dry - thanks for taking the time to complete this part of the survey	

However, we are also interested in your future production plans & views on the Research & Development priorities for the industry. Please refer to pages 9 & 10

2015 Post Harvest Survey

Name (optional)………………………………………………………………….

Summer prune & Trellis dry section

6. What date did you commence summer pruning your vines?

Sultanas	
Naturals	
Sunmuscats	
Sunglo	
Raisins	

7. What date did you commence applying drying emulsion to your vines?

Sultanas	
Sunmuscats	
Sunglo	
Raisins	

8. What rate of drying emulsion was applied ?

Sultanas		**Sunmuscats**		**Sunglo**		**Raisins**	
Oil (L/100L)		**Oil (L/100L)**		**Oil (L/100L)**		**Oil (L/100L)**	
Potash (Kg/100L)		**Potash (Kg/100L)**		**Potash (Kg/100L)**		**Potash (Kg/100L)**	
						Caustic Potash (Kg/100L)	

9.Was a 2nd drying emulsion spray applied? ***please tick***

No		**Go to question 11.**
Yes		**Go to question 10**

Comment: …….

2015 Post Harvest Survey

Name (optional)…………………………………………………………………

10. If yes, what rate was used & how many days after the 1st spray was the 2nd spray applied?

Sultanas		Sunmuscats		Sunglo		Raisins	
Oil (L/100L)		Oil (L/100L)		Oil (L/100L)		Oil (L/100L)	
Potash (Kg/100L)		Potash (Kg/100L)		Potash (Kg/100L)		Potash (Kg/100L)	
Days after 1st spray		Days after 1st spray		Days after 1st spray		Caustic Potash	
						Days after 1st spray	

11.How quickly did the fruit dry?

Days from summer pruning to harvest	
Sultanas	
Sunmuscats	
Sunglo	
Carinas	
Raisins	
Naturals	

12. What was the approximate moisture content of the fruit at harvest?

	% moisture
Sultanas	
Sunmuscats	
Sunglo	
Carinas	
Raisins	
Naturals	

2015 Post Harvest Survey

Name (optional)……………………………………………………………

13. Was the harvested fruit stored in bins before finish drying to less than 13% moisture?

please tick

NO ☐ **if NO go to question 15.**

YES ☐ **No. of days in storage** ☐

If YES go to question 14.

14. What was the date the fruit was harvested to go into storage before finish drying?

Sultanas					
Sunmuscats					
Sunglo					

15. What was your method to finish dry the fruit?

please tick	**Straight of vines dry**	**Bin dehydrated**	**Ground dried**
Sultanas			
Sunmuscats			
Sunglo			
Carinas			
Raisins			

Thanks for taking the time to complete this part of the survey

However, we are also interested in your future production plans & views on the Research & Development priorities for the industry. Please refer to pages 9 & 10

2015 Post Harvest Survey

Name (optional)…………………………………………………………………

Current & Future Production Plans

If you are presently a dried grape grower, do you intend to continue producing dried grapes?

NO ☐ **If NO - When do you intend ceasing producing?** ☐

YES ☐ **If YES - How many years?** ☐

Do you intend to invest in new plantings?

NO ☐

YES ☐ **If yes - When?** ☐ **How many acres?** ☐

Varieties intending to plant? ☐ ☐

Dried Grape Research Priorities

Dried Fruits Australia (DFA) currently manages several research projects for Horticulture Innovation Australia (HIA)

These include:

a. Producing High Value Dried Grapes Stage 2

Full literature review

Best Practice Guide (3 parts. Parts 1 & 2 completed)

On-Farm trials (Advancing maturity/Potassium, emulsion & vineyard floor management)

b. Dried Fruits Knowledge Management System project

Electronic library of research reports & industry documents

c. Dried Grape Evaluation project

Evaluation of dried grape lines, previously bred by CSIRO

d. Industry Development project

Industry Development Officer & related activities

A range of new research projects are being considered at present, including-

e. Dried Grape Evaluation - final stage

f. Breeding new dried grape varieties, using the marker assisted selection (MAS) technique

g. Objective colour measurement of dried grapes

After reviewing the information on current & proposed reseach projects, do you have another issue/problem that should also be considered a priority for the dried grape industry research program?

1……

……..

2……

……

Quest to produce high value dried grapes continues

By Ivan Shaw

In response to an identified 3,000-5,000 tonne market niche for light-coloured sultana-type dried grapes, Dried Fruits Australia, with Horticulture Australia Limited (HAL) support, initiated work aimed at guiding Australian producers to consistently produce light coloured dried grapes.

Stage 1

Maturity and berry colour

The first stage of this work examined the relationship between berry maturity at the time that drying was initiated and final dried grape colour. Crop load manipulation and multiple harvests were used to produce a limited range of maturities. Grapes were dried either on an open rack, or in an oven to remove the effect of weather on final dried grape colour. The comparison confirmed that weather during drying was the single biggest influence on final dried grape colour this season, but when that factor was eliminated, there was no colour penalty associated with high crop loads.

The results underscore the importance of getting crops to mature sooner and dry quickly following summer pruning. Adoption of earlier maturing rain-tolerant varieties is clearly going to be an important part of the industry's future.

Plastic covers

Rain during drying results in darker dried grapes being produced. As most of the Australian dried grape crop is dried on the vine, it is exposed to weather.

The table grape industry uses plastic covers to prevent rain-related grape splitting.

The use of plastic covers on summer-pruned sultana and Sunmuscat was investigated to gain some practical experience on how covers would work on Swingarm trellis, but also to assess the impact of covers on the microclimate in the drying canopies.

The air in drying canopies beneath covers was marginally warmer and dryer than air in canopies that weren't covered, but generally only in the afternoons and only when temperatures were above 20°C. Covers did not prevent drying grapes from being exposed to high ambient relative humidity.

Final dried grape colour was unaffected by covers, but the colour intensity was marginally greater with covers. It wasn't clear whether the higher temperatures and lower air moisture affected how quickly grapes dried. The data highlighted the need to examine vineyard floor and canopy management practices that increase air movement and retention of heat to accelerate drying.

The over-riding factor in the determination of final dried grape colour is the weather during drying. Clearly the impact of weather conditions is more likely to be important when prevailing temperatures decrease as summer ends and autumns starts. Taking every advantage of the generally warmer conditions in February would seem advantageous. Therefore, accelerating ripening and optimising drying conditions to increase moisture loss from grapes following summer pruning would seem to be logical priority subjects for research.

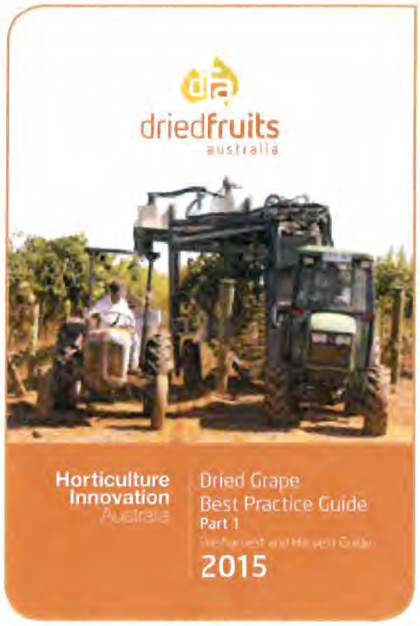
Cultural practices associated with uninhibited and enhanced sugar accumulation by maturing grapes should be investigated and communicated. Obviously, irrigation and fertiliser practices that ensure optimum leaf function without promoting excessive vegetative growth are critical.

But equally, developing management practices that enable vines to cope with adverse weather such as prolonged high air temperature is likely to be important as well.

Accelerating drying would also seem important. Thus, factors including the concentrations of potassium carbonate and dipping oil used, and the number of applications affect the rate of moisture loss from drying grapes and warrant re-visiting.

Equally, because the rate of moisture loss from grapes determines the length of drying, and is likely to be enhanced when the relative humidity of the air surrounding the drying berries is lower, it follows that air movement is critical. Thus, cultural practices (e.g. topping and leaf plucking) that allow better air flow would seem important.

Although some details of the microclimate that drying berries contend with in summer-pruned canopies are now known because of the work described herein, little is known about the movement of air, and its moisture status, through vineyards during the drying process. Knowledge developed in this area may lead to improvements in vineyard design and cultural practices that promote the displacement of moist air around drying berries with dry bulk air.



The Best Practice Guide for the production of high quality, light coloured, dried grapes in Australia, incorporates the latest information from the literature review, Stage 1 project and industry feedback.

To sum up, consideration should be given to:

- acquiring technology to sort and measure the colour of individual dried berries,
- continuing the investigation of the relationship between berry maturity and colour using the above technology, but ensuring a greater spread in maturities by more timely intervention,
- quantifying the maturity variability with berry colour variability using the above technology,
- quantifying the importance of the temperature and relatively humidity differentials associated with covers,
- investigating cultural practices that accelerate crop maturity,
- investigating management practices that accelerate drying and
- investigating the dynamics of air movement into, within and out off vineyards during the drying process.

Stage 2

Stage 2 builds on the outputs of Stage 1. It began in mid-2014 and will run through to about August 2015.

The main objective of both Stage 1 and 2 is to provide growers with access to improved trellis drying management systems that enable consistent delivery of high quality, light coloured dried grapes, as weather conditions during maturation/drying/harvesting and storage become increasingly erratic.

The full literature review covering factors affecting the colour attributes of traditional Australian-style dried grapes at the completion of drying and during storage has helped identify knowledge gaps and changes that need to be made to current management practices.

The industry best practice guide is being prepared by a Project Management Committee with professional guidance from local authors Terry and Jacinta Gange. The *Best Practice Guide for the production of high quality, light coloured, dried grapes in Australia*, incorporates the latest information from the literature review, Stage 1 project and industry feedback.

The final guide will comprise several parts, with the first part (Pre-harvest to harvest) being mailed to growers shortly, providing clear recommendations for the consistent production of high quality, light dried grapes.

Following careful consideration of the findings and recommendations arising from the Stage 1 project and the full literature review several more on-farm trials have been proposed for completion in 2014/15. The project variation request is under consideration by Horticulture Innovation Australia Limited (HIAL).

Proposed on-farm trials

Trial 1. Advancing maturation with potassium

Objective: To assess the impact of potassium sprays on maturity of dried grape varieties of sultana and Sunmuscat

Desired outcome: To advance maturity to take better advantage of higher temperatures and longer days in late summer and early autumn.

Time frame: mid- January to mid-February 2015

Trial 2. Drying emulsion rates to improve drying

Objective: To assess the impact of drying emulsion strength on the time needed to dry fruit to harvestable moisture content.

Desired outcome: To facilitate quicker breakdown of berries and reduce the time taken for berries to dry on the vine and reach a moisture content of 16% or lower.

Time frame: mid-February to early April 2015.

Trial 3. Improving drying conditions in the vineyard

Objective: To assess the impact of vineyard floor management on drying conditions in vineyards for the production of dried grapes.

Desired outcome: To optimise vineyard conditions for quicker drying of fruit.

Time frame: 20 December 2014 to late April 2015.

DG13004 and DG13006 Producing high value dried grapes - stage 1 and stage *have been facilitated by Horticulture Australia Limited (HAL) in partnership with Dried Fruits Australia). The project has been funded by the national dried grape research and development (R&D) levy with the Australian Government providing matched funding for all HAL's R&D activities."*

Ivan Shaw is a grower and Chairs the Project Management Committee.

This cover crop has been sown and will be used for two of the treatments in the vineyard floor management trial.

Producing high value dried grapes – stage 2

Update on field trials

To remain viable in the dried grape industry, every effort must be made to produce light and high quality dried grapes. This hasn't been easy in recent years with adverse weather impacts from rain events at critical times, causing grapes to split and allowing mould to develop pre-harvest and then rain and humid conditions as fruit is near dry, making it turn brown.

Growers are encouraged to take advantage of the longer day lengths and potential for warmer weather early in the drying season to avoid the problems experienced in recent years. However, more research is required to establish the effects of various practices and confirm they will assist growers produce better quality dried grapes.

To this end, Dried Fruits Australia is undertaking three field trials as part of the *Producing high value dried grapes – stage 2* project at the SuniTAFE farm at Cardross. Since the last edition of *The Vine* the trials have been confirmed and an outline of their progress follows.

Data loggers record temperature and relative humidity within the canopy to determine the most effective vineyard floor management practice.

Drying emulsion is applied at various rates to assess the impact on drying rate.

Trial 1: Advancing maturation with potassium

Aim: To assess the impact of potassium sprays on advancing maturity of dried grape varieties of sultana and Sunmuscat

Two potassium sprays were applied to sultana (15 January and 29 January 2015) and Sunmuscat (22 January and 5 February 2015) vines.

Regular berry samples were collected and their maturity measured.

Trial 2: Drying emulsion rates to improve drying

Aim: To assess the impact of drying emulsion strength on the time for fruit to dry to a harvestable moisture content

Four combinations of drying emulsion were applied:

- 0.5% oil & 0.6% potash
- 0.6% oil & 0.8% potash
- 0.8% oil & 1.0% potash
- 1.2% oil & 1.5% potash

Half rows of all treatments were then resprayed after 7 days with a 0.5% oil and 0.6% potash mixture

Regular samples of 100 berries were collected and weighed to measure weight loss/drying.

When dry enough to be moisture tested, fruit samples from all treatments were moisture tested using the Calipco moisture meter.

Trial 3: Improving drying conditions in the vineyard

Aim: To assess the impact of vineyard floor management on drying conditions in vineyards for the production of dried grapes

Data loggers were installed through the vine canopy to measure and log temperature and relative humidity. The loggers will be removed at harvest and results analysed.

Conclusion

The trials are ongoing and at this stage, none of the data has been statistically analysed to determine if the treatments make a significant difference to the rate of drying.

The 2015 harvest and drying season have been extremely kind to growers enabling many growers to produce a greater proportion of high quality and light coloured fruit compared to harvests of recent years.

While growers appreciate the excellent drying conditions this season, it will be difficult to demonstrate the value of these techniques being trialled to advance maturity and facilitate rapid early drying of grapes.

DG13006 Producing high value dried grapes - stage 2 has been facilitated by Horticulture Innovation (HIAL) in partnership with Dried Fruits Australia. The project has been funded by the national dried grape research and development (R&D) levy with the Australian Government providing matched funding for all HIAL's R&D activities.

Members encouraged to register for on-line library

The Dried Fruits Australia website has been reinvigorated with a vibrant new look and more information for growers and consumers.

A key feature of the new design has been the inclusion of a secure members' area which allows Dried Fruits Australia members to access the on-line library and other industry information and reports.

Dried Fruits Australia Chief Executive Phil Chidgzey said the library was one of the outcomes of the Dried Fruits Knowledge Management Project which aimed to collate all the industry references and research data in the one location.

To date more than 550 publications have been scanned and uploaded. They include: R&D reports; papers; best practice information; books;

and past issues of *The Vine* and its predecessor *Dried Fruits* News.

"This project has preserved the knowledge accumulated over several decades, and by bringing it together in the one convenient location, improved its accessibility and usefulness to the industry," Mr Chidgzey said.

"This precious resource is available to both grower and processor members, but will not be open to the general public.

"I encourage all Dried Fruits Australia members to contact the DFA office and register to use the website.

"Browse through the library, you never know what useful tips you may find that may help increase productivity and profitability on the farm."

The registration process is quick and easy, members need to talk DFA Membership Officer Dolores Shaw-Wait, confirm their email address (used as the username) and create a password. This will enable them to access the on-line library and a wide range of industry and research information.

Revised date for New Varieties Field Walk

Selecting which grape varieties to plant and getting the mix of varieties right to manage risk and time and labour inputs can be a difficult decision.

As varieties mature at different times growers are now looking to plant a mix of varieties on their properties. This helps minimise the risk of damage to the fruit from a single rain event and also spreads the workload over harvest.

Over the past few years, Cardross grower, Allan Long has opened his property for a field walk to allow growers to observe his plantings of new sultana type varieties to directly compare the varieties themselves. We are fortunate that he has agreed to do so again.

This will be the last opportunity to see all of the varieties planted as some of the varieties in the demonstration block are going to be removed.

Please note the date of the field walk has changed from the previous notice and will now be held on Sunday 17 January 2016 and will commence at 10:00am. Mr Long's property is situated at the intersection of Westcliffs road and Ropers Road, Cardross.

Further information will be sent to Dried Fruits Australia members through DFA's e-news service.

Diary 2016

JANUARY

17 New Varieties Field Walk, Allan Long's property, intersection of Westcliffs and Ropers Roads, Cardross. Contact Dried Fruits Australia:
T: *(03) 5023 5174.*

FEBRUARY

3-5 Fruit Logistic, Messe Berlin GmbH, Berlin, Germany,
W: www.fruitlogistica.de/en

MARCH

3-4 Global Agriculture Summit 2016, Growing connections for flourishing communities, Dordt College, Sioux Center, Iowa, United States,
W: *www.agrisummit.org*

8-11 Foodex Japan 2016, Makuhari Messe, Chiba, Japan,
W: www3.jma.or.jp/foodex/en

APRIL

5-7 Irrigation New Zealand Conference and Expo 2016, Oamaru, New Zealand,
W: *www.irrigationnz.co.nz/events-training/conference-2016*

12-15 FHA Singapore 2014, Singapore Expo, Singapore,
W: *www.foodnhotelasia.com*

MAY

5-7 SIAL China, Shanghai New International Expo Centre, Shanghai, China,
W: *www.sialchina.com*

8-11 17th HOFEX, Hong Kong Convention and Exhibition Centre, Hong Kong.
W: *www.hofex.com*

10-13 Seoul Food Hotel 2016, Korean International Exhibition Center, Seoul, South Korea.
W: www.seoulfoodnhotel.co.kr

13-14 Riverina Field Days, Griffith Showgrounds.
W: *www.riverinafielddays.com*

Producing high value dried grapes

Dried Fruits Australia's Producing high value dried grapes project has been a major area of research for the past 18 months as the industry works to regain European markets and lift overall returns to growers.

The project has recently been extended to enable the three on-farm trials to be repeated this season, and gives us the opportunity to recap on some of the major findings to date.

Stage 1

Stage 1 of the project began in 2014 with the initial focus examining the relationship between berry maturity at the time drying was initiated and final dried grape colour. It confirmed that weather during drying was the biggest influence on final dried grape colour, but when this factor was removed, there was no colour penalty associated with large crop loads.

The use of plastic covers on summer-pruned sultanas and Sunmuscat was also investigated to gain some practical experience on how covers would work on Swingarm trellis and to assess the impact on the microclimate in the drying canopy.

Covers did not prevent drying grapes from being exposed to high ambient relative humidity. Final dried grape colour was unaffected by covers, although colour intensity was greater with covers.

The stage 1 report suggested that taking every advantage of the generally warmer conditions in February would seem advantageous. Therefore, accelerating ripening and optimising drying conditions to increase moisture loss from grapes following summer pruning would seem to be logical priority areas for further research.

Stage 2

Stage 2 of the project saw the completion of a full literature review *Producing High Value Dried Grapes* and the compilation and distribution *of Best Practice Guides (parts 1-3)* which were finalised and distributed during 2015

Three on-farm trials were also conducted as part of Stage 2 and in our previous report, it was noted that while growers would appreciate the excellent drying conditions in 2015, "it will be difficult to demonstrate the value of these techniques being trialled to advance maturity and facilitate rapid early drying of grapes".

This early prediction proved to be very accurate and we experienced a rare season in which grapes dried rapidly despite some growers' poor preparation.

Trial 1. Advancing maturation with potassium: On balance, there was no evidence that the formulation used in the Californian trials has the same effect on the accumulation of total refractable soluble solids (TSS) in the two main Australian drying varieties in season 2015. This conclusion needs to be qualified by empirical observation that maturation in the 2014-15 season was earlier than normal which may have had an impact on the effectiveness of the formulation.

> *"Hort Innovation has approved an extension of the Producing high value dried grapes project to August 2016."*

Trial 2. Drying emulsion rates to improve drying: The report concluded that under such a perfect drying conditions:

- Emulsion strength was only a significant source of variation on the moisture content of drying fruit early in the drying process (i.e. up to about DoY 55 or about a week after cutting/emulsion application);
- Aspect (i.e. the orientation of the Swingarm, and hence the fruiting side) had no influence on drying; and
- A second emulsion application did not hasten drying of sultanas, but provided a small advantage with Sunmuscat.

Trial 3. Improving drying conditions in the vineyard: This trial aimed to assess the impact of vineyard floor management on the temperature and relative humidity of the air in the vineyard during trellis drying as a the basis for identifying conditions that will result in fruit drying more rapidly.

The plan had been to compare the air above three vineyard floor management strategies, namely:

- bare compact earth,
- mulched dry cover crop/volunteer weeds on vineyard floor, and
- green standing cover crop.

However, a miscommunication resulted in all the cover-cropped inter-row areas being slashed, and effectively reducing the trial to a single comparison of mulched vineyard floor surface versus a bare vineyard floor surface.

The report concluded:

- The air adjacent to the drying grapes was more likely to be drier if the vineyard floor was bare compared to the vineyard floor being covered in a layer of mulch.
- Irrespective of vineyard floor management, the air adjacent to the drying grapes was more likely to be warmer than the bulk air.
- The range of relative humidity and temperature differentials for the bare soil surface part of the planting was greater for that part of the vineyard with a bare soil surface compared to that part of the vineyard with a mulched soil surface.

Repeat of on-farm trials in 2016

Hort Innovation (HIA) has approved an extension of the project to August 2016, to enable the three on-farm trials to be repeated in 2016.

Dried Fruits Australia explained that the 2015 season had been ideal for fruit development with the result that fruit maturity was earlier than normal. The harvest period saw the best weather conditions for drying fruit that had been experienced for many years. Hot dry weather prevailed throughout the drying and harvest period until mid-April creating ideal conditions for growers to dry and harvest their fruit before the April rain.

While ideal for dried grape producers, the weather conditions were not considered to be 'normal' for a typical drying and harvest period. These conditions meant that the rationale behind the field trials, which sought to more rapidly dry grapes by increasing exposure to higher daytime temperatures and thus reducing exposure to adverse weather, could not be fully tested.

Dried Fruits Australia will repeat the on-farm trials in 2016, when an 'average season' is likely with drying interrupted by rain event(s) enabling these project objectives to be tested.

Project update: Producing high value dried grapes

Michael Case catches fruit from the harvester for sampling in Trial 2.

Harvest of the Drying Emulsion Rates field trials.

Dried Fruits Australia initiated the Producing high value dried grapes project to try and help growers determine industry practices that would lead to consistent production of quality, light coloured dried fruit.

The original project had three main components:

- Full literature review – to capture all relevant research and industry information relating to the production of high quality, light dried fruit
- Best Practice Guide (3 parts) – with clear recommendations for the consistent production of high quality, light dried fruit
- On-farm trials – three trials related to the broad objective of improving the likelihood of growers being able to produce quality, light coloured dried fruit by reducing the time of exposure to adverse weather conditions during the drying process.

The on-farm trials are the final component in the original project and were conducted during the period January to April 2016. The data collection has been completed and the analysis is currently being undertaken with the results included in the final report due 31 August, 2016.

On-farm trials

Three trials were devised from the outcomes of the literature review and development of the *Best Practice Guide*.

- Trial 1: Advancing maturation with potassium (to assess the impact of potassium sprays on maturity of dried grape varieties of sultana and Sunmuscat)
- Trial 2: Drying emulsion rates to improve drying (to assess the impact of drying emulsion strength on the time needed to dry fruit to harvestable moisture content)
- Trial 3: Improving drying conditions in the vineyard (to assess the impact of vineyard floor management on drying conditions in vineyards for the production of dried vine fruit)

It should be noted that Hort Innovation approved a project variation to enable the same field trials to be repeated in 2015/16 when an 'average season' was likely with drying interrupted by rain event(s) enabling the project objectives of maximising the exposure of drying grapes to higher day time temperatures for longer and minimising the exposure of the fruit to the vagaries of the weather, to be tested.

Minor changes were made to the drying emulsion rates trial and the improving vineyard drying conditions trial treatments to further test the underlying principles. No changes to the advancing maturity with potassium trial were planned.

Trial 1: Advancing maturation with potassium

Waiting for soluble solids (predominantly glucose and fructose) in berries to attain suitable levels is at a cost of potentially being unable to take advantage of better high temperatures, longer day lengths and low relative humidity drying conditions. Application of potassium (K) (as potassium metalosate) in California has been shown to advance sultana maturity by approximately 8-14 days.

Potassium metalosate (24% K) was applied twice at a rate of 7L/ha (equivalent to the 1.5lbs of K/acre quoted in the Californian study). The first application took place for sultana in mid-January, and the second a fortnight later. The first application for Sunmuscat took place in the 3rd week of January, and the second a fortnight later.

Whole rows were sprayed and fruit from those rows compared to the fruit from unsprayed rows separated from sprayed rows by 2 unsprayed rows (guard rows).

Berries (2 from the top, 2 from the middle and 1 from the bottom) were sampled from bunches down the row, and refractable soluble solids determined using a temperature-compensated digital refractometer.

A sample was collected prior to the first spray application and at 7-10 day intervals subsequently.

Observations in 2016

- The raw data suggests that there was no advancement in maturity this season.
- Some control fruit samples were riper than treatment samples.
- As a result of this leaf samples were collected from all treatments and controls, dried and sent away for analysis.
- It is possible that there may have been a disproportionate imbalance of foliage vs crop which may have limited the effect of the K sprays.
- Also, the potassium status of the US trial sites and the local TAFE trial site is unknown.

Please note – the trial data is still being analysed and will be included in the final report.

Trial 2: Drying emulsion rates to improve drying

Taking full advantage of the higher temperatures, longer day lengths and drier air in late summer/early autumn is critical in maximising the initial breakdown of berry skins. The drying emulsion strength used to initiate and hasten this process is also critical.

Trellis drying emulsion rates that were used:

a) 0.25% oil and 0.30% potassium carbonate (half the current industry standard for trellis drying)

b) 0.5% oil and 0.6% potassium carbonate (oil to potassium carbonate ratio of 0.83, and the current industry standard for trellis drying);

c) 0.67% oil and 0.8% potassium carbonate (oil to potassium carbonate ratio of 0.83);

d) 1.04% oil and 1.25% potassium carbonate (oil to potassium carbonate ratio of 0.83 and approximately half the strength of the old standard dip mixture for rack drying).

Each treatment was applied to two full rows on Swingarm trellis with rows facing both directions (North and South).

Depending on the weather and the initial berry break-down, a follow up spray of 0.5 % oil and 0.6 % potash was applied 6-7 days after the initial application.

The rows were further divided into halves, and a second spray applied to one half.

Sultanas - 1st emulsion spray applied 16 February and re-sprayed 22 February

Sunmuscats - 1st emulsion spray applied 22 and 23 February and resprayed 29 February

Fruit was harvested when moisture content had been reduced to 16% with samples being retained for colour assessment.

The remains of a cover crop after the wetting of emulsion in the vineyard floor treatments trial.

Observations in 2016

- It appears that the second spray application of 0.5% oil and 0.6% potash had a clear effect on the quality of the fruit sample especially with the lower rates for the initial emulsion applications, 0.25% oil and 0.3% potash and 0.5% oil and 0.6% potash.
- This effect was more evident on Sunmuscat.
- It was also noted that the samples taken in the mornings and the high rates of emulsion, 1.04% oil and 1.25% potash with the second spray of 0.5% oil and 0.6% potash seemed to be 'doughier' (re-absorbed moisture overnight) than the lower rate treatments.

Please note – the trial data is still being analysed and will be included in the final report.

Trial 3: Improving drying conditions in the vineyard

The aim of this trial was to assess the impact of vineyard floor management on the air temperature and relative humidity of air in the vineyard during trellis drying as the basis for identifying conditions that would make fruit dry quicker, particularly when ambient temperatures were high, the air drier and the days long.

Three vineyard floor management strategies were compared:

e) bare compact earth,

f) mulched dry cover crop/volunteer weeds on vineyard floor and

g) green standing cover crop.

h) A minimum of 6 rows and up to 10 rows per treatment with the trial rows in the centre of the patches.

The green cover crop of millet was sown earlier and allowed to establish. The mulched treatment was lightly mulched a number of times, and allowed to re-grow enabling the accumulation of a higher mulch level on the vineyard floor.

The bare earth treatment was sprayed with herbicide early to maintain compacted soil and to avoid sunburn at véraison.

Temperature and relative humidity (RH) were measured at 0.5, 1.5 and 3m above the soil surface in the vine row. Logging temperature and RH sensors were installed in Stevenson Screens. The loggers were set up and running well prior to cutting, but had to be removed for 1 day when wetting and cutting took place, and were re-installed until harvest.

Observations 2016

- Fruit from the cover crop treatment when moisture tested using the Calipco moisture meter was wetter than the mulch and bare earth treatments.
- The data from the data loggers which recorded both temperature and relative humidity, before and after summer pruning, will be analysed.

Please note – the trial data is still being analysed and will be included in the final report.

Producing high value dried grapes

Literature Review

HAL DG13006 December 2014

Karl Sommer

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9 Conclusions and recommendations

Climate

- Significant rain during drying is probably the single most detrimental factor in achieving mature trellis dried fruit of light colour. Short and medium term weather forecasts are essential for planning and deciding crucial operations around trellis drying and should be used in conjunction with maturity monitoring to predict drying progress and anticipated harvest dates.

Emulsion

- Current emulsion composition is near optimal and applied volumes are adequate. Applied volumes for trellis drying are high but are used to ensure good coverage inside dense bunches and clumps of bunches on the trellis.
- Factors associated with optimal emulsion delivery should be re-valuated. They include precise targeting of sprays through manifolds, including nozzle sizes, pressure and drive speed.
- The effect of silicone based wetters appears to be restricted to the initial stages of drying and benefits to fruit quality are most likely restricted to unfavourable drying conditions. It would be useful to re-evaluate their effectiveness in preventing dark fruit.
- There is little or no information on the use of antioxidants like sulfur or metabisulfite when applied at the time of cane cutting for trellis drying. Potential benefits may result from the prevention of enzymatic and non-enzymatic browning if wettable sulfur, sulfur dust or metabisulfite were applied with or shortly after the drying emulsion.
- The documented work on emulsion composition and rates historically has focused exclusively on Sultana. The drying of alternative varieties like Sunmuscat may therefore benefit from a re-evaluation of currently recommended emulsion compositions and rates.

Maturity

- Average maturity and the variance of the maturity of single berries is the most crucial factor in achieving uniformly light coloured fruit. Maturity also varies strongly across or between vineyards and between seasons. Measures with potential to accelerate maturity and uniformity of bud burst and flowering should be considered for evaluation. These include use of chemical sprays of hydrogen cyanamide (CN_2H_2) to synchronise bud burst.
- Maturity should be monitored closely to avoid processing of immature, green fruit of high acidity.

Canopy management

- Vine spacing and trellis configuration have an impact on the potential for air circulation within and between vine rows. Tall trellises with open canopies facilitate air flow under the vines and between vine rows. Regular skirting of the leaf canopy will further assist air flow between vine rows.
- Increased vine spacing reduces vigour with potential benefits for bunch distribution and structure through a reduction in bunch density and berry size. Both should improve emulsion cover and drying rate. Reduced vigour may result in a less dense foliage cover with improved ventilation and air flow for drying.

- At pruning time shoots should be evenly positioned to avoid potential clumping of bunches that will be difficult to wet.
- Records of the temperature profile of trellis drying berries in various positions on the vine as well as inside and outside bunches would be useful to assess positional effects within the trellis as well as trellis orientation, and to quantify the effect of management interventions like leaf stripping and vineyard floor management. They would allow quantifying the drying progress in relation to general weather records which in turn might be useful in predicting drying progress.
- Leaf removal prior to cutting the canes for drying will increase the air flow around the drying bunches and thus reduce humidity while improving direct absorption of radiant sunlight by bunches. Impact of leaf removal on drying rate and canopy microclimate should be quantified.
- Ideally, vine vigour should be balanced such that shoot and leaf coverage is sufficient to prevent sunburn of fruit but sparse enough to allow adequate light penetration and canopy ventilation. Appropriate canopy parameters similar to wine grape production should be determined.

Floor management

- Floor management practices suitable for mechanised dried fruit production must facilitate the trellis drying operation. It should therefore include the total elimination of weeds and cover crops well before cutting the canes for drying. A clean and dry vineyard floor is likely to reflect radiation into vineyard canopy and will facilitate the heating and drying of bunches.
- Effects of vineyard floor management, including reflective covers, on the bunch and berry temperatures and drying rate should be evaluated.

Nitrogen

- A strategy to reduce berry nitrogen supply has potential benefits for the prevention of non-enzymatic browning during storage but at the same time may promote enzymatic browning during the drying process on the vine or rack.

Irrigation

- Irrigation should cease shortly before or immediately after canes have been cut to accelerate drying and vines should not be irrigated during the drying period particularly with overhead or low level sprinklers with complete ground cover. If the vineyard is equipped with drip emitters vines may be irrigated during the drying period.

Roostocks

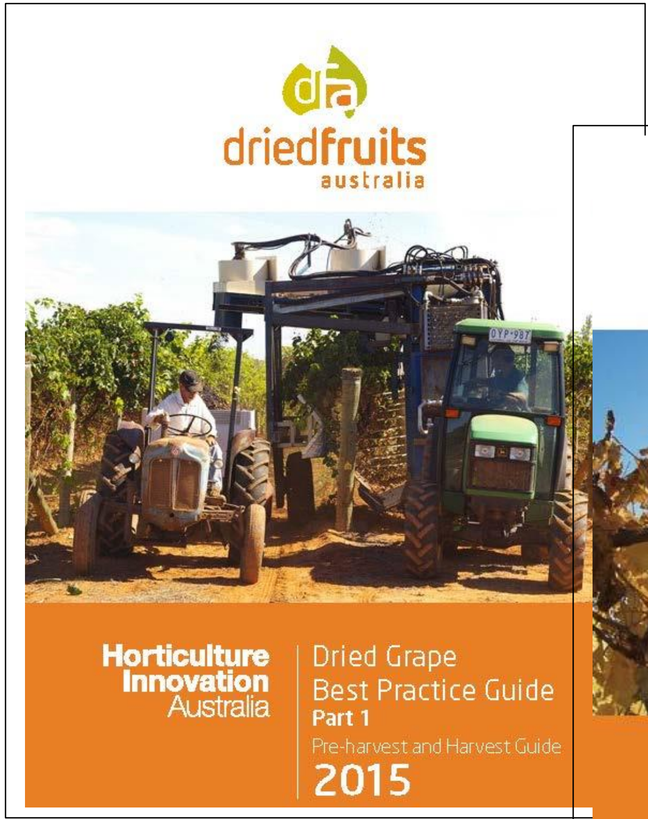
- The relatively limited fruitfulness and high vigour of Ramsey grafted Sultana contribute to the production of large, dense bunches with big berries which are difficult to cover and penetrate with drying emulsion and are likely to dry slowly.
- Sultana on alternative rootstocks like Lider 187-24 or 1103 Paulsen is likely to produce lighter coloured fruit than on Ramsey. Lider 187-24 should be readily available to industry.

Varieties

- Equal probability of rain throughout the drying months in Australia makes it desirable to plant and develop additional rain-fast and early-maturing varieties.

On farm storage

- Fruit should be stored in sealed containers at a moisture content between 12 and 13%. Storage of even moderately moist fruit should be avoided to prevent sugar extrusion which may lead to "puggy" fruit prone to rapid browning in storage after processing.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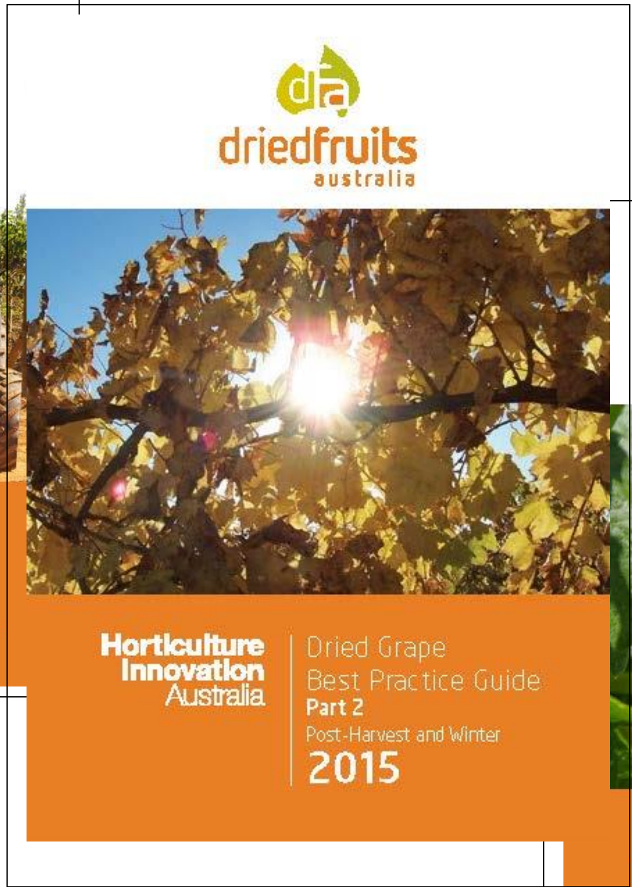
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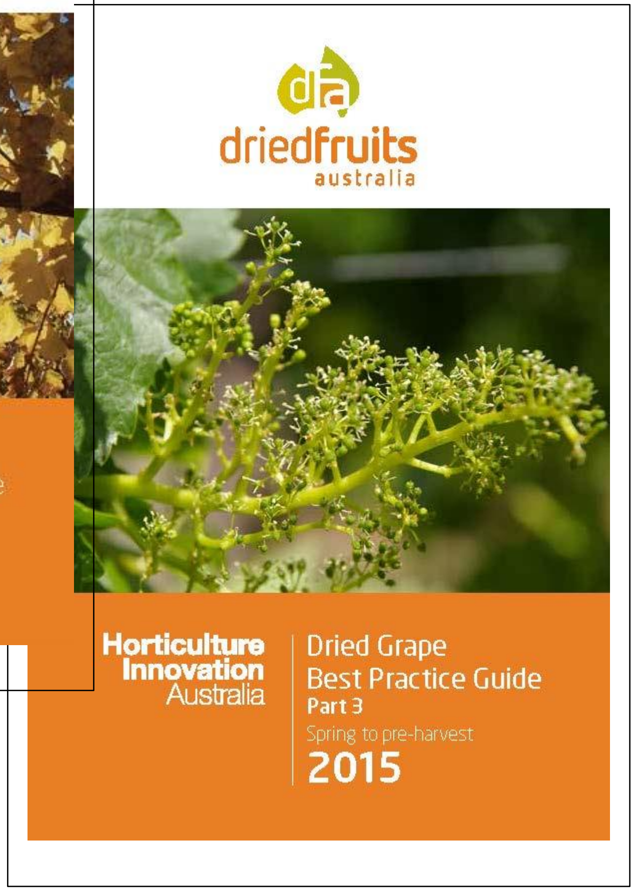
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