Effect of season on crop development of Carina, Sultana and Sunmuscat

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Background

Inconsistent yield performance of the major varieties is a significant issue for the dried grape industry. Recent studies, which compare the performance of Carina, Sultana and Sunmuscat grafted on high vigour conferring rootstocks over 10 seasons (2014-23) has provided a unique opportunity to compare their crop development and yield consistency.

Materials and methods

The trial was planted in 2011 at the CSIRO Irymple farm near Mildura, Victoria, in sandy soil (Tilpa sand) in rows spaced 3 m apart with a vine spacing of 2.45 m, giving 1360 vines per hectare. It included 3 commercial rootstocks (Ramsey, 1103 Paulsen and 140 Ruggeri), 2 new high performing CSIRO rootstocks (Dominant and Vibrant) and a further unnamed selection which were bench grafted with Carina, Sultana and Sunmuscat. There were 3 replicates of each scion x rootstock combination. The vines were managed on a high cordon hanging cane trellis system with all fully developed canes retained at pruning and drip irrigated with 7.2 ML/ha each year. For Carina, a standard Cycocel (300ppm) and GA (10 ppm) setting spray was applied at 70-80% flowering.

The data used in this study covered 10 seasons, 2014 to 2023. The site was impacted by a severe hailstorm on 11th November, 2016 which caused significant canopy loss and damage to shoots and bunches. There were no losses due to disease in any season. Each variety was hand harvested separately, based on maturity. Means for all measured parameters were based on averages across all rootstocks. Prior to harvest, berry samples were collected to determine mean berry size and fruit maturity. At harvest, yield and bunch number were recorded and used to calculate mean bunch weight. Mean berries per bunch was calculated from the berry weight and the mean bunch weight, ignoring the rachis weight. To account for differences in sugar concentrations between the varieties, total sugar per vine partitioned to the crop was calculated based on yield and maturity at harvest (total sugar per vine = yield x ^{o}Brix/100).

Correlation analysis and multilinear regression models were used to determine the relative influence of bunch number, berry weight and berries per bunch on yield and to develop a regression equation for yield of each variety across the seasons. Counting of flowers per inflorescence prior to flowering, which may influence the number of berries set, was not included in this study.

Results and discussion

Fruit maturity at harvest was in line with commercial expectations for each scion variety with respective mean total soluble solids of 24.4, 20.7 and 24.0 ^{o}Brix for Carina, Sultana and Sunmuscat. Respective mean harvest dates over the 10 seasons for Carina, Sultana and Sunmuscat were 13th, 9th and 28th February. Over the 10 seasons, there were significant differences in fresh yield between the varieties. Carina delivered the highest yield and variability between seasons, with mean ± standard deviation of 35.2 ± 14.0 kg/vine, while the yield and seasonal variability of Sultana and Sunmuscat was lower, respectively 31.7 ± 8.4 and 29.8 ± 7.6 kg/vine. Highly significant interactions between year and variety for yield and its components indicate that each variety responded differently to environmental cues affecting crop development and productivity each season (Figure1). Over the 10 seasons, there were significant differences in calculated sugar harvested per vine between the varieties with respective means of 8.33, 6.36 and 7.00 kg/vine for Carina, Sultana and Sunmuscat which equates to 11.3, 8.7 and 9.5 t/ha of harvested sugar.

For Carina, the yield ranged from 15.2 kg/vine in 2014 to 57.2 kg/vine in 2023, trending upward over time, except for the hail-affected 2016-17 season. Carina appears to take longer than the standard 3-4 seasons to reach full production. Significant correlations with year (r = 0.91) indicate that the increased yield was associated with higher bunch weights (r = 0.81) linked to an increase in berries per bunch (r = 0.81) over time. The yield of Sultana showed significant fluctuations from season to season ranging from 10.1 kg/vine in the 2016-17 hail-affected season to 41.1 kg/vine in 2023. Sultana also produced a high yield of 39.0 kg/vine in 2014, the first significant crop. Results for later seasons (2018-22) suggest that the hail-induced low crop in season 2016-17 initiated a biennial bearing response. Significant trends over time showed increased Sultana bunch weight (r = 0.60) and berry weight (r = 0.74). Productivity of Sunmuscat was reasonably consistent over time, apart from the high yields in 2022 and 2023 (i.e. 40.1 and 47.4 kg/vine), and largely unaffected by the hail in 2016, most likely because of the retention of bunches that would normally abort before harvest (Clingeleffer and Tarr, 2023). The lowest yield for Sunmuscat was in 2020 (24.2 kg/vine). The high productivity of all varieties in 2022 and 2023 can be linked to the development of large bunches associated with large berries, and in the case of Sultana and Carina in 2023, a high number of berries per bunch (fruit-set). These effects can be attributed to the very mild climatic conditions in these seasons.

The results across the seasons reflect the inherent differences between the three varieties in crop development. On average, Carina had the highest bunch numbers (366/vine), the smallest bunches (99 g), the smallest berries (0.74 g) with 136 berries per bunch. In contrast Sultana had the lowest number of bunches (82/vine) but produced the largest bunches (394 g), a berry weight of 1.79 g with the most berries per bunch (219). Sunmuscat had 171 bunches/vine, a bunch weight of 176 g, the largest berry weight (2.38 g) and the least berries per bunch (69).
Factors contributing to the inherent differences in crop development between the varieties require further study. They could include the impacts on bunch number of canes retained at pruning; the number of nodes per cane possibly associated with differences in internode length; differences in budburst (shoots per node) and shoot fruitfulness and differences between varieties in fruit set and bunch loss between spring and harvest.

Multilinear regression techniques were used to develop model equations for each of the scions. The highly significant equations ($R^2 > 0.98$) describe the combined effects of the contributing factors to seasonal yield variability.

Carina: Yield = -61.24 + 0.08 Bunches + 52.05 Berry wt. + 0.21 Berries/bunch
Sultana: Yield= -44.20 + 0.29 Bunches + 13.34 Berry wt. + 0.13 Berries/bunch
Sunmuscat: Yield = -52.96 + 0.15 Bunches + 12.46 Berry wt. + 0.38 Berries/bunch

For all varieties, the main driver of yield across seasons was bunch weight (R^2 = 0.75, 0.49 and 0.82 for Carina, Sultana and Sunmuscat respectively) rather than bunch number.

For Carina, bunch weight across seasons correlated with both berries per bunch (r = 0.93) and berry weight (r = 0.82). Stepwise regression modelling showed that berries per bunch accounted for 57% of the variation in yield between seasons, berry weight a further 24% and bunch number a further 18%. This result indicates that fruit set is most probably the key factor in explaining the seasonal variation in Carina yield although the potential influence of flower number per inflorescence cannot be excluded. The fruit set response may have been impacted by the timing of the setting spray across the rootstocks, nominally at 70-80% cap fall.

For Sultana, bunch weight across seasons correlated with both berries per bunch (r = 0.92) and berry weight (r = 0.82). Stepwise regression modelling showed that berries per bunch accounted for 51% of the variation in yield between seasons, bunch number a further 39% and berry weight a further 9%. The results suggest that growers should minimize stress at flowering to optimize Sultana fruit set. The results for Sultana grafted on high vigour rootstocks and managed on modern trellises, indicate that seasonal factors that affect bunch development are more important than the temperature and light conditions around flowering in the previous season, which have been linked to bud and shoot fruitfulness and hence bunch number (Clingeleffer 2010).

For Sunmuscat, bunch weight across seasons correlated with both berry weight (r = 0.85) and to a lesser degree, with berries per bunch (r = 0.62). Stepwise regression modelling showed that berry weight accounted for 73% of the variation in yield between seasons, berries per bunch a further 11% and bunch number a further 14%. Bunch number was not expected to be a critical determinant of yield as Clingeleffer and Tarr (2023) found significant losses, up to 40% in the number of bunch inflorescences between spring and harvest in response to crop load. It is, however, somewhat surprising, that berries per bunch (fruit-set) was reasonably constant and not a key factor in yield variability between seasons. Previous short term Sunmuscat studies identified fruit set as a critical factor (Singh and Treeby 2009) and that every precaution should be taken to avoid stress during the fruit set period as it was sensitive to deficit irrigation (Sommer et al. 2014). The low number of berries per bunch of Sunmuscat in this study is however consistent with the results reported indicating low fruit-set (Singh and Treeby 2009). It is possible that Sunmuscat fruit-set may have been enhanced by application of Cycocel, which would have retarded shoot growth and reallocated carbohydrate resources to the developing bunch (Singh and Treeby 2009).

Conclusion

The results show that each of the three dried grape varieties responded differently to the environmental cues affecting crop development in each season, although bunch weight was the key driver of yield for all varieties. For Carina bunch weight was associated with berries per bunch. This is most likely due to environmental effects on fruit-set, although differences in flower number between seasons could also be a contributing factor. For Sultana berries per bunch, bunch number and berry weight were all important factors contributing to yield variation. For Sunmuscat, bunch weight, associated with berry weight, was the main driver of yield. For all varieties, further research is required to identify if variation in berry number per bunch is associated with differences in flower number or fruit set. Further research is also required to identify the environmental cues impacting berry development from season to season.

References

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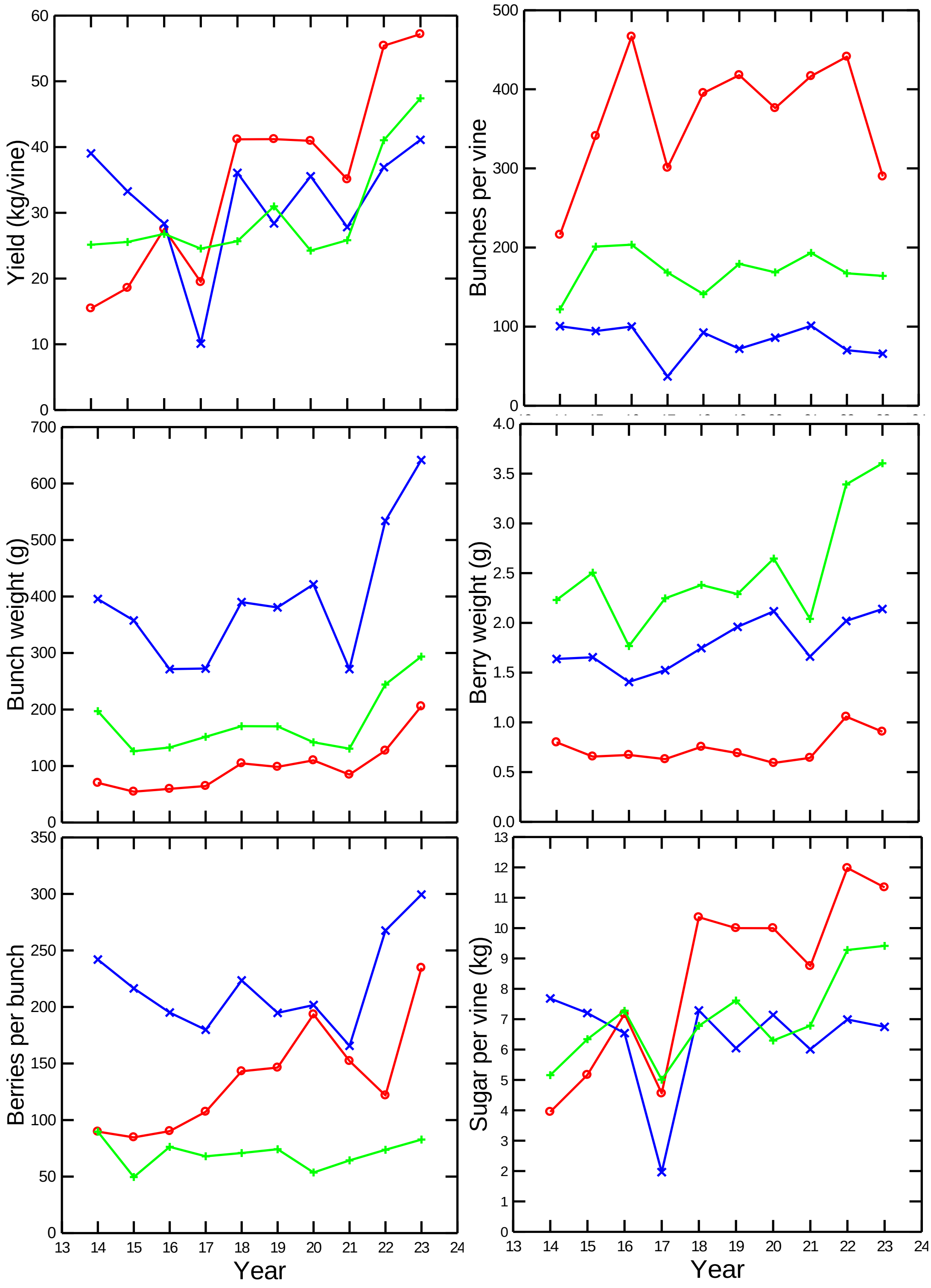

Figure 1. Effect of season (2014-23) on yield per vine, its components (bunch number per vine, bunch weight, berry weight and berries per bunch) and harvested sugar per vine of Carina (red), Sultana (blue) and Sunmuscat (green).