| CFPA<br>Canning Fruit Producers' Assoc.<br>Submit to:<br>Wiehahn Victor<br>Tel: +27 (0)21 872 1501<br>inmaak@mweb.co.za | SAAPPA / SASPA / SAT<br>Fruitgro Science<br>Submit to:<br>Louise Liebenberg<br>Tel: +27 (0)21 882 8470/1<br>louise@fruitgro.co.za | DFTS<br>Dried Fruit Technical Services<br>Submit to:<br>Dappie Smit<br>Tel: +27 (0)21 870 2900<br>dappies@dtd.co.za | Winetech<br>Submit to:<br>Jan Booysen<br>Tel: +27 (0)21 807 3324<br>booysenj@winetech.co.za |
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| | | | x |

Indicate (X) client(s) to whom this final report is submitted.
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# FINAL REPORT
## FOR [Click HERE and type year]

### PROGRAMME & PROJECT LEADER INFORMATION

| | Programme leader | Project leader |
|---|---|---|
| **Title, initials, surname** | Prof. A. Deloire | Dr. P.A. Myburgh |
| **Present position** | Professor in Viticulture | Senior Researcher |
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### PROJECT INFORMATION

| | |
|---|---|
| **Project number** | KB-02 |
| **Project title** | Interactive effect of temperature and irrigation on grape composition during berry development in Cabernet Sauvignon |
| **Project Keywords** | Environmental conditions, grape maturation |

| | | |
|---|---|---|
| **Industry programme** | **CFPA** | |
| | **Deciduous** | |
| | **DFTS** | |
| | **Winetech** | X |
| | **Other** | |

| | |
|---|---|
| **Fruit kind(s)** | Wine grapes |
| **Start date** (dd/mm/yyyy) | 01 Nov 2007 |
| **End date** (dd/mm/yyyy) | 31 Jan 2010 |

(Note: adjust footer – insert the project number no, researcher and research institution)

# FINAL REPORT

## 1. Executive summary

The aim of the study was to describe how Cabernet Sauvignon grapevines react to climate and irrigation within the Swartland region. Due to the proximity to the Atlantic Ocean, the study area could be divided into two viticultural climatic regions. Grapevines near Philadelphia closer to the ocean experienced less water constraints compared to those further inland near Wellington. Stem water potential could also be related to soil water matric potential, which tended to have a more pronounced effect on grapevine on water constraints further inland. In the warmer climate, severe constraints reduced yield. Under the latter conditions, grapes started to ripen earlier than those in the cooler climate. Sugar per berry was highest where grapevines experienced moderate constraints. These seemingly balanced grapevines had the highest sugar accumulation, probably due to optimum photosynthesis and carbohydrate utilization. Low water constraints increased vegetative growth which could have been a sink for sugar loading. In addition to sugar loading, ˚B increases could also have been due to a concentration effect. Therefore, ˚B is probably not a representative indicator of grapevine functioning. Sugar and anthocyanin biosynthesis, *i.e.* on a per berry basis, could be co-regulated. Anthocyanin biosynthesis reached a plateau when the sugar content reached 200 mg/mL to 220 mg/mL. At véraison, the most intense grape colour occurred where grapevines experienced moderate water constraints, *i.e.* irrigation near Wellington and no irrigation near Philadelphia. At harvest, grapes from the cooler climate tended to have more intense colour and higher phenolics, indicating that lower temperatures favoured anthocyanin biosynthesis. Water constraints tended to increase sensorial wine colour intensity, as well as wine fullness. Moderate water constraints at both localities produced better wine quality as opposed to severe constraints. In warmer climates, moderate water constraints required to achieve balanced grapevine functioning can be obtained with irrigation, but this might not be the case in cooler climates.

## 2. Problem identification and objectives

Most viticultural field trials attempt to explore the influence of a single variable, e.g. plant water status, on one or more aspects of grape and/or wine composition. The current study attempted to carry this further, by looking at interactive effects between two or more variables in grapevines grown in climatically distinct localities, namely temperature and plant water status. These interactive variables will be used to model berry ripening in Cabernet Sauvignon in the Swartland, and attempt ultimately to predict the response of certain key phenolics: anthocyanin and tannin, to variation in temperature, water, or both. Under conditions of both varying temperature and water status, a wide variation in fruit composition will be obtained. Most viticultural studies explore the response of grapes to a simplified winemaking process where only a few variables produce a limited variability in grape composition (e.g. KB-01). Since the current study will potentially produce a wide variation in grape composition, with variables affecting grapevine performance closely modeled, a closer correlation between grape composition and wine composition than previously will be a potential outcome.

## 3. Workplan (materials & methods)

This study was part of a larger project carried out by the Infruitec-Nietvoorbij institute of the Agricultural Research Council at Stellenbosch, *i.e.* Project WW13/14. The primary objectives of this particular project were to determine effects of soil type and climate on yield and wine quality of Cabernet Sauvignon. The larger project was carried out in selected grape growing regions, *i.e.* Stellenbosch, Swartland, Lower Olifants River and Lower Orange River. The initial objective was to determine the impact of sunlight and temperature on flavonoids of Cabernet Sauvignon grapes and wines at different maturity levels. However, due to accuracy problems concerning the concentration of some compounds in the juice and wine, particularly tannins, the project concentrated on sugar loading and anthocyanin biosynthesis only in the Swartland region. Details of the trial sites, treatments, experimental layout, and sampling procedures, measurement protocols, analytical procedures and statistical methods have already been reported and published (Mehmel, 2010; Myburgh, 2011).

## 4. Results and discussion

| **Milestone** | **Achievement** |
|---|---|
| 1. Site selection and establishment of irrigation trial. | Completed |
| 2. Acquisition and insertion of temperature probes, with continuous monitoring of canopy temperature. | Completed |
| 3. Continuous soil monitoring. | Completed |
| 4. Appointment of M.Sc. student, Tara Mehmel. | Completed |
| 5. Monitoring of grapevinevine water during the season, and monitoring of vegetative response in terms of leaf area and winter pruning weight. | Completed |
| 6. Monitoring of berry ripening pre- and post-veraison, *i.e.* measuring TSS, pH and TTA. | Completed |
| 7. Harvest grapes at the same TSS level. | Completed |
| 8. Prepare small-scale wines from each plot. | Completed |
| 9. Optimisation of method for the spectrophotometric determination of tannin in grapes and wines. | Aborted |
| 10. Analysis of tannin and anthocyanin composition of grape samples using spectrophotometric techniques. | Only anthocyanins completed |
| 11. Analyse wine samples specifically be for the development of total colour, tannin and polymeric pigment. | Completed |
| 12. Wines will be sensorially analysed by a trained panel for an estimate of sensorial wine quality and sensory properties. | Completed |
| 13. Statistical analyses (MRA/PLS/PCA) will be carried out to determine relationships between temperature, ripeness, water applied and flavonoid content of berries and wines, extraction and stability of flavonoids during winemaking, and overall wine quality. | Aborted |
| 14. Completion of MSc thesis by student. | Published August 2011 |

The results were reported and discussed in detail in a Master's Thesis (Mehmel, 2010). Only the general discussion and conclusions of the Thesis will be presented in this final report.

In the Coastal region of the Western Cape, proximity to the Atlantic Ocean plays an important role in describing the potential for viticultural cultivation. On a regional macro climatic scale, the Swartland region is generally classified as having a hot climate, where the temperature increases with distance from the ocean. As a result, climate varies on a meso scale. Two distinct climatic regions in the Swartland, *i.e.* Philadelphia and Wellington which are respectively 12 km and 51 km from the Atlantic Ocean, were identified in this study. Based on Mean February Temperature, Philadelphia was classified as having a moderate climate and Wellington as having a hot to very hot climate. This was confirmed by the Winkler Index, whereby Philadelphia and Wellington were Class III and Class V, respectively. The Heliothermal Index also confirmed the classification into two temperature classes. The Cool Night Index however, showed no difference between the two localities.

The soil chemical and physical properties were comparable at the two sites. Therefore, these factors could be eliminated as reasons for causing different grapevine responses. Due to the similarity of soils at the two sites, root densities were comparable. Although the soil water holding capacities of the two soils were comparable, it does not rule out the possibility that the volume of irrigation water applied will influence grapevine functioning. When the climate is warmer, irrigation could have a more prominent effect on grapevine response than under moderate conditions. Irrigation volumes induced different grapevine water constraints in terms of midday water potential. Stem water potential showed to be a more sensitive indicator of grapevine water status compared to leaf water potential, and was linearly related to the soil matric potential. Water constraints at Wellington could be classified as being mild to moderate and strong in the irrigated and non-irrigated grapevines, respectively. In the moderate climate at Philadelphia only mild water constraints occurred, irrespective of water application. Therefore, grapevines closest to the ocean tended to experience less water constraints over the course of the day compared to ones further inland. This effect could become more pronounced as the season progresses, not only due to the changes the atmospheric conditions, but also as a result of drier soil. The effect of the warmer climate on grapevine water constraints could be modified by irrigation, but in the moderate climate, irrigation had almost no effect. This showed that the grapevine water status was directly dependent and related to soil water status and climate. Climate appeared to be the driving factor in determining water constraints at Philadelphia, whereas the soil water content played a more prominent role at Wellington. These results indicated that the measurement of diurnal leaf water potential cycles at different phenological stages is required to fully understand the effect of the climate and soil on the grapevine water status. Warmer sites have a higher evaporation and transpiration demand compared to cooler climates, therefore placing a greater demand on the plant available soil water. Grapevines in the warmer climate at Wellington required the application of water to alleviate severe constraints, as they seem to function optimally under moderate constraints. Optimal grapevine functioning means the vegetative and reproductive growth of the grapevine is balanced. This was evident in the moderate constraint conditions, namely single drip line at Wellington and non-irrigated at Philadelphia. Therefore, the climate is an important consideration in irrigation scheduling.

The general vegetative growth response to water application and seasonal temperature differences showed that shoot length, leaf area and cane mass increased with an increase of water availability and cooler climate. Moderate water constraints could balance vegetative and reproductive growth, and limit shoots to the desired length of *ca.* 1.2 m recommended for producing and ripening optimal quality Cabernet Sauvignon grapes. Irrigation and lower temperatures at Philadelphia tended to increased berry size, whilst severe water constraints and warmer temperatures, which limited optimal grapevine functioning, had the opposite effect at Wellington. Consequently, yield increased with a decrease in grapevine water constraints induced by the application of water.

Higher temperature, and the increased heat summation units, directly influenced the phenological ripening of the grapevine. Bud burst of grapevines near Wellington tended to occur about two weeks before Philadelphia. Berry ripening and sugar loading also occurred earlier at Wellington. The harvest date seemed to be water constraint related. At each of the two sites, grapes experiencing moderate water constraints reached the desired ripeness level of 24˚B first. This suggested that water constraints at the two localities influenced the photosynthetic activity of the grapevines. Results from this study confirmed that the grapevine water status influenced berry volume and the dynamics of berry ripening.

More moderate climate seemed to limit and, to some degree, retard the sugar accumulation in the berries because minimal water constraints experienced by the grapevine resulted in excessive vegetative growth. At Wellington, the desired sugar level could not be reached probably because of the inhibition of photosynthesis resulting from higher water constraints and temperature. Sugar concentration (mg/ml) was the highest in plots where moderate water constraints occurred, as balanced grapevines had the highest sugar accumulation, probably due to optimum photosynthesis and carbohydrate utilization. Vegetative growth was a sink to the detriment of sugar loading. It was clear that ˚B increased throughout the season. However, this increase was not always as a result of sugar loading, but could also have been due to a concentration effect because of smaller berries caused by water and temperature constraints. Therefore berry volume, rather than Balling, seemed to be a more reliable indicator of grapevine functioning than Balling.

The berry sugar content of grapevines in most of the plots reached the plateau of sugar loading. The only exception was where grapevines growing near Philadelphia were irrigated by means of a single drip line. Anthocyanin biosynthesis in the grapes, as quantified on a per berry basis, showed that sugar loading and anthocyanin biosynthesis were co regulated, with anthocyanin biosynthesis reaching its plateau when the sugar content per berry was between 200 mg/mL to 220 mg/mL. Grapes with the most colour at véraison were produced under moderate water constraints, namely single drip line irrigation near Wellington and non-irrigated conditions near Philadelphia. However, at harvest, grapes from the cooler climate tended to have the more intense colour and higher phenolics. This was probably because anthocyanin biosynthesis was favoured by the cooler temperatures of approximately 20˚C closer to the ocean.

The best sensorial wine colour was produced from grapes where moderate water constraints induced balanced vegetative and reproductive growth, allowing for optimal exposure to sunlight and grapevine functioning required for optimal ripening of all berry components. Deficit irrigation tended to increase sensorial wine colour intensity, as well as the fullness of the wines. This may have been caused by the indirect effect of reduced vegetative growth which could have improved bunch micro climate and, consequently stimulated anthocyanin biosynthesis. The concentrated metabolites could also have contributed to the increased sensorial wine fullness. Moderate water constraints, irrespective of climate, produced the best quality wine in terms of classical sensorial evaluation. This trend was in agreement with previous studies which showed that restricted irrigation inducing moderate water constraints can enhance wine colour and quality. The sensorial wine quality increased with an increase in fullness, which in turn increased with the optimal functioning of the grapevine.

Irrespective of climate, water was shown to be the primary factor affecting grapevine functioning on a vegetative and grape berry level in the Swartland region. It can be concluded that vineyards in the warmer areas in this particular region will require some irrigation to alleviate severe water constraints and allow moderate water constraints favourable for balanced grapevine growth. In contrast, grapevines in the deeper soils in the cooler areas might require no irrigation since the climate-soil interaction can result in moderate water constraints which could be favourable for optimal plant functioning. However, this does not negate the importance of canopy management practices to obtain specific cultivar and wine styles in the different climatic regions in the Swartland region.

## 5. Literature references

Mehmel, T.O., 2010. Effect of climate and soil conditions on Cabernet Sauvignon grapevines in the Swartland region with special reference to sugar loading and anthocyanin biosynthesis. Thesis, University of Stellenbosch, Private Bag X1, Matieland 7602, South Africa.

Myburgh, P.A., 2011. Determining the contribution of soil water status and selected atmospheric variables on water stress in grapevines. ARC Project WW13/14, Final report to Winetech, P.O. Box 528, Paarl 7624, South Africa.

## 6. Accumulated outputs

<u>Technology development, products and patents</u>
None

<u>Human resources development/training</u>

| | Student level (BSc, MSc, PhD, Post doc) | Cost to project (R) |
|---|---|---|
| 1. | MSc | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |

<u>Publications (popular, press releases, semi-scientific, scientific)</u>
Mehmel, T.O., 2010. Effect of climate and soil conditions on Cabernet Sauvignon grapevines in the Swartland region with special reference to sugar loading and anthocyanin biosynthesis. Thesis, University of Stellenbosch.

<u>Presentations/papers delivered</u>
Mehmel, T.O., Effect of climate and soil conditions on Cabernet Sauvignon grapevines in the Swartland region with special reference to sugar loading and anthocyanin biosynthesis. Thesis defence, University of Stellenbosch, 27 October, Stellenbosch.

## 4. Total cost summary of project

| | Year | CFPA | Deciduous | DFTS | Winetech | THRIP | Other | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **Total cost in real terms for year 1** | | | | | | | | |
| **Total cost in real terms for year 2** | | | | | | | | |
| **Total cost in real terms for year 3** | | | | | | | | |
| **Total cost in real terms for year 4** | | | | | | | | |
| **Total cost in real terms for year 5** | | | | | | | | |
| **TOTAL** | | | | | | | | |