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# Factors affecting the predisposition of 'Cabernet Sauvignon' grapevines (*Vitis vinifera* L.) to the physiological disorder, bunch stem necrosis.

A thesis presented in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

in

Plant Physiology

at

Massey University, Palmerston North, New Zealand.

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2006

# Abstract

Bunch stem necrosis (BSN) is a physiological disorder in grapes. It results in shrivelled berries with poor quality attributes such that wine produced from grapes with high BSN incidence is of compromised quality. Past research has proposed many different hypotheses to explain the disorder. Literature indicates that conditions during certain stages of development may predispose berries to BSN but results are not consistent as to which stage is the critical one or which factors have the most impact. This study was designed to resolve these points of uncertainty. Treatments that either enhanced or decreased vine vigour, or manipulated the light environment around the fruit zone were applied to field grown 'Cabernet Sauvignon' vines over three seasons. Treatments included root pruning, heading back of canes by 50%, laying down a reflective mulch and two 50% shade treatments applied for three weeks either pre- or post-full bloom (FB). A strong positive correlation was found between vine vigour and the incidence of BSN. Three weeks post-FB, during both the current and previous season, was identified as the critical period within which factors predispose bunches to BSN. Plant growth regulators, including $GA_3$, IAA and NPA, were applied to bunches on a different group of field grown vines immediately after FB. Application of $GA_3$ during the critical period, tended to reduce the incidence of BSN, while the effects of IAA and NPA application were less clear and require further research. In a controlled environment (CE) trial, pot-grown vines were placed in CE rooms during one of three development stages. Results showed that treatments applied during the critical three-week period after FB increased the incidence of BSN three fold compared with no change in BSN incidence for vines that were placed in the CE rooms immediately prior to FB or prior to veraison. Collective results from these studies clearly demonstrate that the period immediately following FB is the most critical time in the predisposition of bunches to BSN. It is suggested that competitive dominance of vegetative growth over the developing inflorescence and bunch for assimilates and/or nutrients may be the predisposing factor/s influencing this disorder.

I would like to dedicate this thesis to my grandfather, Dr Owen Haylock (1923 – 2002). Without him in my life, the desire and motivation to even start this thesis would not have been there. Sadly he died before he could see me start this study, but his memory has been with me throughout the four years of this research.

# Acknowledgements

So many people and organisations have helped me over the last four years, without who I would not have accomplished what I have. I would like to thank as many of them as I can.

The most important person I would like to thank is my chief supervisor, Prof. Ian Warrington. Without his knowledge, guidance, understanding, patience, and motivation I would not have managed to undertake such a large project or even completed this thesis. I was extremely privileged to have him as my supervisor for the entire course of study and to also have him mucking in, out in the field, with spade, secators, pen and paper.

Secondly, my co-supervisor Dr David Woolley, who I have had many a long discussion with, that have helped me immensely with formulating and clarifying many of my ideas. Thank you for stepping in when you were needed.

Also, Drs Steve McArtney and Jens Wunsche, whose knowledge and help was greatly appreciated even though their time associated with my study was not as long as was originally planned. Thank you to Dr Siva Ganesh, who guided me through so much of my statistics and who, without his help, and I would have been lost in a statistical world. Also, Dr Damian Martin, who got the ball rolling for this study and assisted me to gain my research funding.

Thanks to my two main helpers, Jake Bixley and Ben van Hooijdonk, who assisted in data collection from my field trial. The extensive amount of data that I collected, and sadly have not been able to report all of, would not have been possible without these two.

Thank you so much to AGMARDT for my doctoral scholarship that kept me fed and housed through out my study, and Winegrowers New Zealand, who with out their financial support this study would never have been started. Also, thanks to Extenday Ltd, who provided the Extenday mulch used in this study.

My thanks also for the grape vines, analyses and extensive help I received from all the people at Pernod-Ricard, especially David Werry, who guided me in my viticultural knowledge, George who looked after my field vines so well, and Adam for putting up with a student on his block. Also, Justin, Teresa and the others in the lab who tirelessly analysed my juice samples for me.

To all my colleagues and friends at HortResearch and Massey University, especially at the PGU, INR and The Soils Department, whose help and advice has been fantastic, thank you. Thank you also to HortResearch for allowing me to go on leave without pay, while still allowing me to have an office and use equipment throughout my study.

And finally thanks to my friends and family who have put up with me over the last four years. My grandmother for her love and occasional financial support, my mother for helping me with sample taking and spending many an hour proof reading my thesis, and especially my husband, Phil, who has stuck by me through my bad moods, occasional desire to chuck it all in and late nights at the computer (and the desire to kill the thing). He has supported me not just emotionally but has been there as a sounding board for ideas, helped collect data, written computer programs to help with my data, and built approximately five computers for me, as I killed them off one by one.

To all of you, and so many other people I have not been able to thank as it would take a second volume, thank you so much for what you have done for me.

# Extended Thesis Summary

Bunch stem necrosis (BSN) is a physiological disorder in grapes that results in unripe shrivelled berries with poor quality attributes. This includes the Brix concentration remaining low, while titratable acidity (TA) remains high. Visual symptoms include not only the shrivelled or flacid appearance of the berries, but necrosis of the rachis, peduncle or pedicels. Symptoms usually occur soon after 100% veraison has been reached and progressively worsens until harvest. Wine produced from grapes with a high proportion of BSN is consequently low in quality and therefore the disorder is of concern to the industry. Past research results are conflicting, with many different hypotheses being proposed to explain the disorder. Although symptoms are not exhibited until after veraison, the literature indicates that conditions during certain stages in development may predispose berries to BSN. However, the literature is not consistent as to which stage is the critical one or which factors have most impact on the disorder. This study was designed to try and identify this possible critical stage in berry development and the factors that impact on the severity of BSN.

For two seasons 50% shade cloth was applied to field grown 'Cabernet Sauvignon' vines. One group received shade for three weeks prior to full bloom (FB) with a second group receiving shade for three weeks immediately following FB. Assessments including juice analyses and non-destructively estimating BSN incidence from veraison to harvest were carried out. Raw BSN incidence data were adjusted for days after 50% veraison and a common Brix/TA ratio in order to accommodate any differences in maturity among treatments and compare the incidence of the disorder across all three seasons where BSN incidence was assessed. In Season Two, plant growth regulator treatments, which included $GA_3$ (50 mg $l^{-1}$), IAA (200 mg $l^{-1}$) and NPA (200 mg $l^{-1}$), along with a control, were applied to bunches on a different group of field grown 'Cabernet Sauvignon' vines immediately after FB. This was in combination with canopy manipulation treatments of removing laterals from vines and retaining the laterals, that were also carried out immediately after FB and continued through the growing season. In a controlled environment (CE) trial, potted 'Cabernet Sauvignon'

vines were placed in CE rooms for three weeks during one of three stages: immediately prior to FB, immediately after FB and for three weeks prior to veraison. The controlled environment room conditions were set at 23/11°C day/night temperatures for the entire length of the experiment. Day length was 16 hours with an 8 hour night. Photosynthetic photon flux (PPF) was set at 600 ± 15 μmolm$^{-2}$ s$^{-1}$, which is considered to be close to optimum for photosynthesis on grapevines. Contrasting relative humidity (RH) conditions (40 and 80% RH) were included within the treatments.

Shade prior to FB tended to reduce BSN incidence in both seasons in which the shade cloth was applied (Figure A). Assessments carried out in the third season, where shade cloth was not applied, found no change in BSN incidence. Adjusting the data for days after 50% veraison and the maturity ratio made no difference to any of the conclusions drawn for all three seasons.

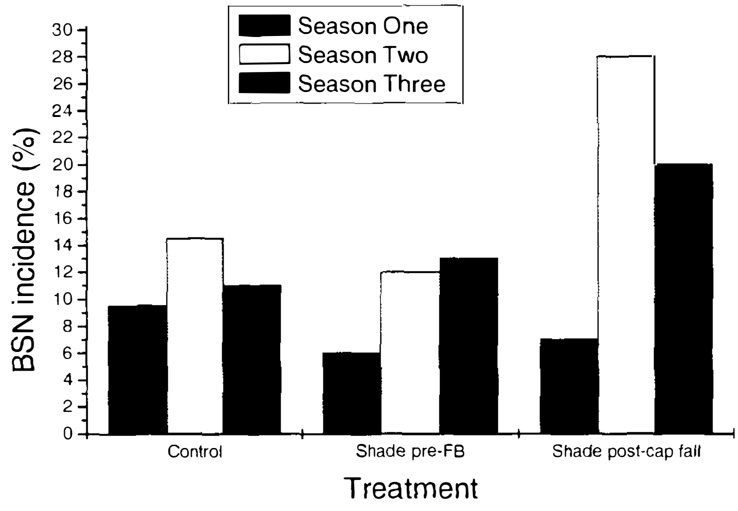


**Figure A: BSN incidence (%) over three seasons of control vines and vines treated with 50% shade cloth applied for three weeks prior to FB and three weeks post FB. Shade treatments were only applied in Seasons One and Two. Values are adjusted to a common maturity ratio of 1.8 in order to compare across all three seasons.**

Shade immediately after FB did not significantly affect BSN incidence in the first season, although there was some indication that it may increase the disorder. In the second season shade applied immediately after FB significantly increased the incidence of BSN and in the third season assessments showed that shade applied after FB in the previous season significantly increased the incidence of BSN (Figure A). When the data were adjusted for days after 50% veraison and the maturity ratio similar conclusions could be drawn.

Various treatments that affected the vegetative growth of vines were also applied to 'Cabernet Sauvignon' vines during Seasons One and Two. These included root pruning, which was carried out during the winter months in Season One, heading back of the canes by 50% and the application of a reflective mulch, Extenday™, both of which were applied in Seasons One and Two. A second group of vines were root pruned in Season Three. Point quadrat analysis was carried out on these treatments, as well as the two shade treatments, during Seasons One and Two. Leaf layer number was determined to be a good measure of vine vigour and was also significantly correlated with the incidence of BSN (Figure B). Although point quadrat measures were carried out from FB to harvest, it was determined that the measurement approximately three weeks after FB represented the differences in vigour among treatments after FB the best. It was therefore this assessment which was used. The correlation demonstrated that treatments that reduced vine vigour after FB reduced the incidence of BSN.

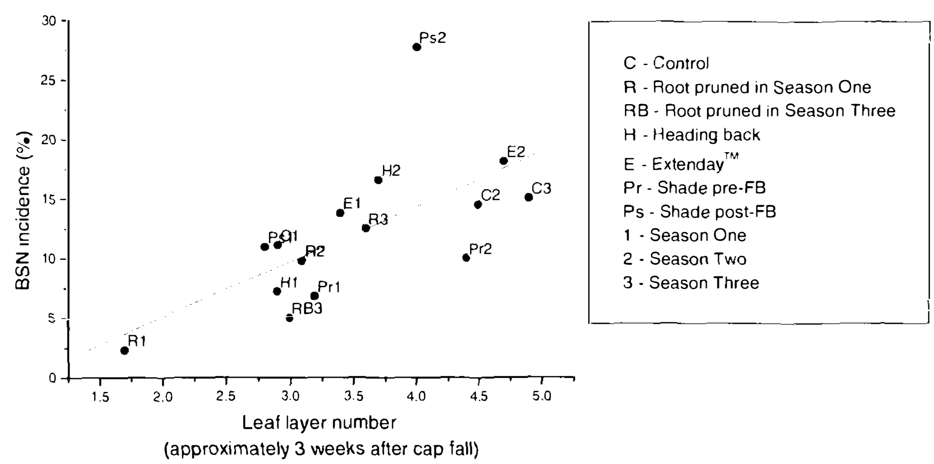


**Figure B: Correlation between leaf layer number approximately three weeks after FB and BSN incidence (%) across all three seasons. Y=4.6x – 4.21, $R^2$ = 0.65, p=0.0085.**

Application of $GA_3$ increased berry size, and consequently bunch weight, delayed maturity and tended to reduce the incidence of BSN (Figure C). Compared to control bunches, application of IAA and NPA tended to reduce BSN incidence in vines where laterals were removed, but not in vines where they were retained. However, BSN incidence in IAA and NPA treated bunches tended not to be different between vines with laterals removed or retained (Figure C). Therefore, any difference in BSN incidence that these plant growth regulator treated bunches had compared to control bunches, may have been due to an increase in BSN incidence of control bunches on vines with laterals removed. Further research is therefore required to determine the effect of NPA and IAA on BSN incidence and the mechanisms involved.

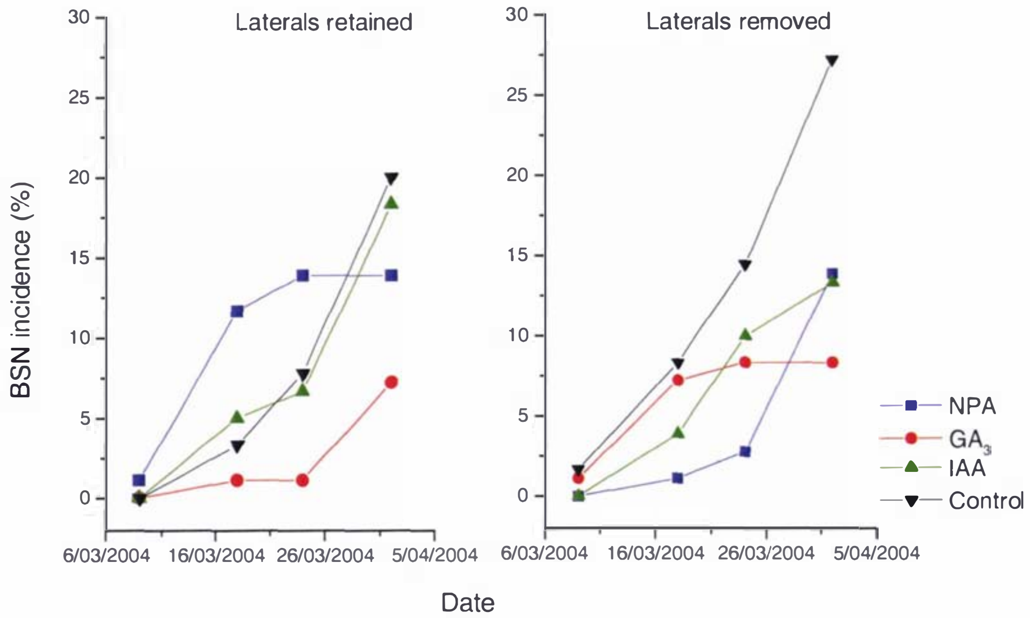


**Figure C: BSN incidence from 100% veraison to harvest in Season Two for canopy manipulated vines of laterals retained (control) and laterals removed and plant growth regulator dipped bunches of NPA, $GA_3$, IAA and control.**

In the controlled environment (CE) studies, vines that were placed in the CE rooms immediately prior to FB and prior to veraison did not demonstrate a difference in BSN incidence compared to control vines. However, vines that were placed in the CE rooms after FB had an approximate three fold increase in BSN incidence compared to all other vines (Table A). Relative humidity did not impact on the disorder.

**Table A: Mean BSN incidence (%) for bunches from vines placed in the CE rooms at either one of three stages. Stage One – pre-FB, Stage Two – post-FB, Stage Three – pre-veraison. Means for vines not placed in the CE rooms also included (control).**

| Stage | 14 March 2005 | 24 March 2005 | 30 March 2005 |
|---|---|---|---|
| One | 8.3 | 24.5 b | 26.5 b |
| Two | 38.8 | 69.4 a | 76.0 a |
| Three | 6.9 | 15.6 b | 27.0 b |
| Control | 4.5 | 14.3* | 24.2* |

Means within a column with a different letter are significantly different from each other at $P \leq 0.15$ (LSMeans, SAS).

*Control means not used in statistical analysis

Results from these studies clearly demonstrate that the period immediately following FB is the most critical time in the predisposition of bunches to BSN. Conditions during this time not only affected the incidence of BSN in bunches of the current season, but also in the following season. It is suggested that competitive dominance of vegetative growth over the developing inflorescence and bunch for assimilates and/or nutrients at this development stage may be the predisposing factor/s. Therefore management techniques that reduce vegetative growth during the time immediately after FB, such as root pruning during dormancy, can reduce the incidence of BSN.

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# List of Abbreviations

| | |
|---|---|
| ABA | abscisic acid |
| AD | apical dominance |
| $A_{max}$ | light saturated photosynthetic rate |
| ANOVA | analysis of variance |
| BSN | bunch stem necrosis |
| BTOA | benzothiazole-2-oxyacetic acid |
| Ca | calcium |
| $CaCl_2$ | calcium chloride |
| $Ca(NO_3)_2$ | calcium nitrate |
| CE | controlled environment |
| CN | cane number |
| CsCl | cesium chloride |
| dT | temperature increase of the sap |
| EBSN | early bunch stem necrosis |
| ECN | effective cane number |
| ECW | effective cane weight |
| FB | full bloom |
| GAs | gibberellic acids |
| $GA_n$ | gibberellic $acid_n$ – n denotes the acid number |
| Gs | stomatal conductance |
| GPN | growing point number |
| GP/C | growing points per cane |
| GPW | growing point weight |
| HCl | hydrochloric acid |
| $HNO_3$ | nitric acid |
| IAA | β-indole-3-acetic acid |
| IBA | 3-indolebutyric acid |
| IN | inflorescence necrosis |
| K | potassium |
| Ksh | thermal conductance constant for a particular gauge |
| LCP | light compensation point |
| LLN | leaf layer number |
| LSD | Fisher's protected least significant difference |
| LSE | light saturation estimate |
| LSMeans | Least significant means |
| Mg | magnesium |
| $MgCl_2$ | magnesium chloride |
| $Mg(NO_3)_2$ | magnesium nitrate |

| | |
|---|---|
| $MgSO_4$ | magnesium sulphate |
| NAA | 1-naphthalene acetic acid |
| NPA | naphthyl-phthalamic acid |
| PD | primigenic dominance |
| PIL | percent interior leaves |
| PG | percentage gaps |
| Pn | net photosynthetic rate |
| PPF | photosynthetic photon flux |
| PW | pruning weight |
| QE | quantum efficiency |
| Qf | heat convection carried by sap |
| RBD | random block design |
| RH | relative humidity |
| SAS | SAS system for statistical analysis |
| $SrCl_2$ | strontium chloride |
| SrCs | strontium and cesium |
| $Sr(NO_3)_2$ | strontium nitrate |
| TA | titratable acidity |
| TIBA | 2,3,5-triiodobenzoic acid |
| Tr | transpiration rate |
| VPD | vapour pressure deficit |