GRAPE AND WINE RESEARCH AND DEVELOPMENT CORPORATION
FINAL REPORT

Project Number:	**DAV 4V**
Project Title:	**Identification and correction of soil acidity induced problems in vineyards, particularly those using micro-irrigation and fertilisation.**
Field of Research:	**Cultural Practices** **Field Code:** **3**
Organisation:	**Department of Agriculture Victoria**
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Report Summary

Vineyards have been planted on naturally acidic soils with a pH below recommended levels in the Central Highlands, Yarra Valley and North Eastern Victorian regions and in areas like the Adelaide Hills and south of Perth. Further serious acidification to a depth of at least 60 cm in the wetting pattern of drip irrigation systems has been shown to occur from the use of acidifying nitrogen fertilisers and inefficient application practices. In conjunction with other work at Tatura the project has provided a basis for improved management of acidic soil conditions.

Results have shown that surface applied liming materials do not increase the soil pH below 10 cm - 15 cm. Fertigation with a soluble alkali increased pH at depth on very light textured soils but was not considered to be cost effective or practical in most conditions. The best strategy in new vineyards is to correct soil pH before planting by mixing lime to the required depth (up to 60 cm) in the vine line and using improved nitrogen fertiliser management practices as described below.

Longer term acidification can be minimised by avoiding mono ammonium phosphate (MAP) and ammonium sulphate. However all fertilisers containing ammonium, including urea, can acidify soil under normal conditions. Results have shown that soluble fertilisers can be leached to below 45 cm depth in the first 1 to 2 hours of an irrigation leading to some direct loss of fertiliser below the root zone and acidifying the entire depth of the root zone. The best practice has been shown to be adding fertiliser very late in the irrigation, eg. over 30 minutes starting one hour before the end of irrigation. This will optimise the fertiliser position high in the root zone where

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at least part of the residual acidification may be neutralised by surface applied lime. In vineyards with a soil pH below 4.5 ($CaCl_2$) pure nitrate fertiliser should be used and applied more often in smaller doses. Under these conditions nitrate based fertiliser slowly reverses soil acidification and is the only form of nitrogen residually available to the vine.

Project Detail

1. Objectives

The original objectives of the project were as follows:

1. To define the extent of soil acidity in established and developing vineyard regions.
2. To develop a sampling and analytical technique to define appropriate strategies for pre-planting correction of low soil pH.
3. To develop a sampling and analytical approach for precise correction of low soil pH problems in established vineyards.
4. To establish the influence of low pH and associated/induced toxicities on vine performance.
5. Examine the movement of forms of nitrogen in the micro-irrigation wetting pattern and their contribution to acidification.
6. Develop and test alternative methods of nitrogen fertiliser application to minimise acidification.

At the start of the project Mr Peter Hayes, State Viticulturalist, was co supervisor of the project. With his departure to the Grape and Wine Research Development Corporation late in the first year of the project the objectives were re-negotiated to remove 4 and to increase the emphasis on 5 and 6.

Throughout the project trials were conducted on commercial vineyards and data from related work on orchards was incorporated where appropriate.

2. Trial Results

2.1 Liming trials.

2.1.1 Surface applied lime.

Acidic soils are known to be widespread in Central, Southern and North Eastern Victoria and soil samples from a number of vineyards over these regions confirmed that many were close to or below pH 5 ($CaCl_2$) for at least part of the rooting depth.

Three sites were selected as follows:

1. Mount Helen - Tisdall's vineyard in North Eastern Victoria. Soil type - sandy loam.

2. Yarra Valley - St Huberts vineyard. Soil type - clay loam.

3. Avoca - Langi Ghiran vineyard in the Central highlands. Soil type - sandy clay loam.

At each site lime was applied at a rate of up to 10 tonne/ha in year one and soil samples taken to a depth of 50 cm at 10 cm intervals each winter and analysed by the standard method using $CaCl_2$ solution. All treatments were replicated 5 times.

The year 3 results are shown in Figures 1 and 2, and demonstrate that there was no effect at a depth of 10 cm - 20 cm at any site. In the lighter soil types pH increased at 5 cm and 10 cm. It was not possible to determine whether this shallow effect was due to earthworm activity or direct movement of lime. Earlier results in years 1 and 2 showed similar trends and there is no indication at any site that the pH at and below 20 cm could increase over a longer treatment period.

2.1.2 Deep mixing of lime

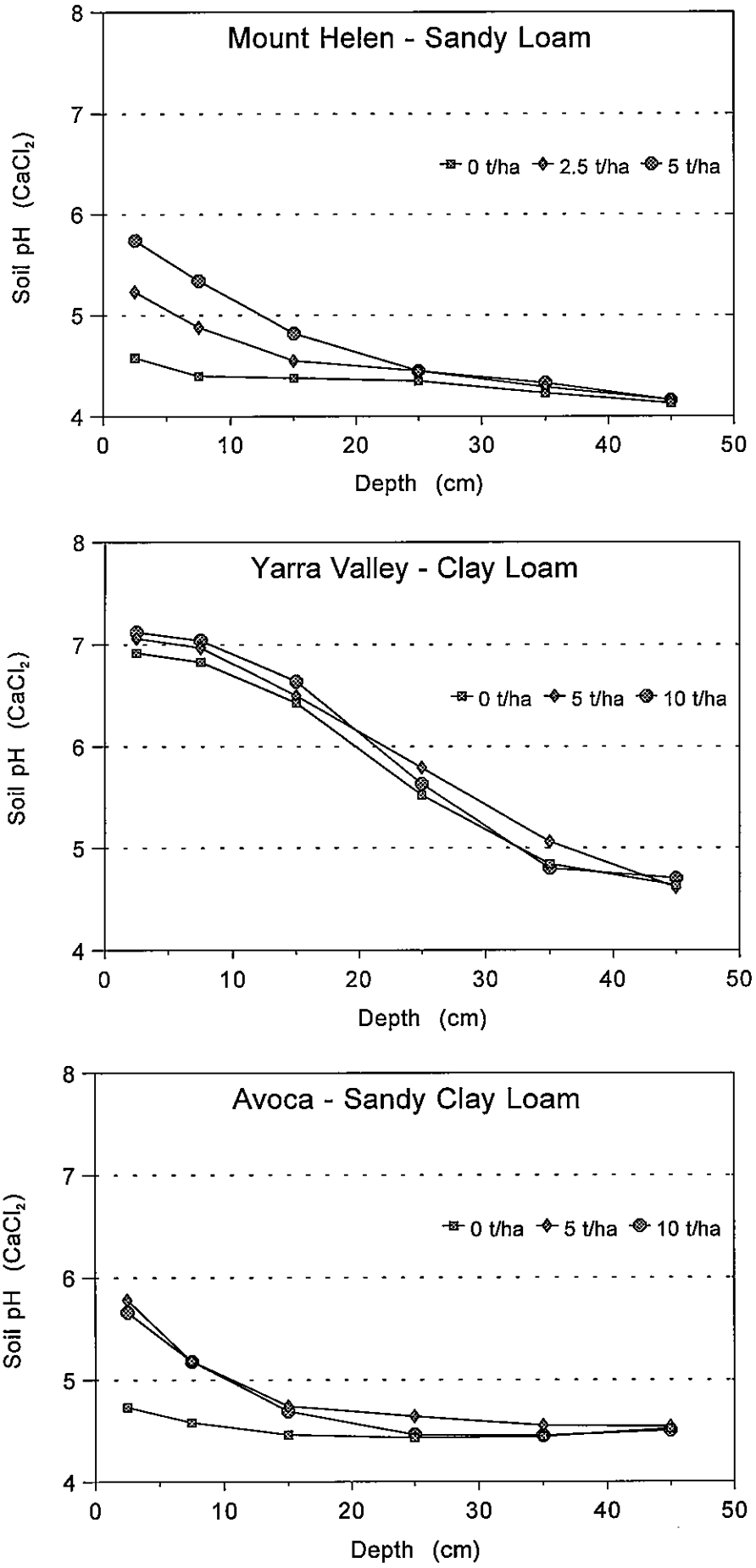
At the Mt Helen site soil preparation was carried out in year 2 for a new vineyard. Lime at a rate of 8 t/ha was deep cultivated in the vine line followed by hilling up in the vine line with adjacent surface soil. Soil samples were taken one year later.

The results (Table 1) demonstrates that incorporation of lime has the expected effect but also shows the practical difficulty of achieving an effect below 30 cm.

Table 1: Lime incorporation before planting at Mt Helen. Soil sampled 12 months after lime application.

Depth	Soil pH ($CaCl_2$)	
	Unlimed	Limed
0 - 15 cm	4.6	6.5
15 - 30 cm	4.5	5.3
30 - 45 cm	4.4	4.7

Figure 1: Surface applied lime trial. Results three years after application.



2.2 Fertilisation with soluble alkali.

2.2.1 Effect of $NaHCO_3$ on soil pH in the trickle wetting pattern.

Earlier laboratory data had indicated that pH could be increased at depth by fertigating with alkali materials like $NaHCO_3$. A trial was conducted at the Mt Helen site in 1989/90 to fertigate $NaHCO_3$ at a rate of 200 g per wetting pattern with the application continuing over the first 6 hours of an 8 hour irrigation followed by a 2 kg gypsum treatment to alleviate any undesirable effects of the sodium. The results (Table 2) demonstrated that soil pH was raised by approximately 1 pH unit in the top 30 cm and 0.5 pH units at 30 cm - 40 cm. The level of exchangeable aluminium was decreased by $NaHCO_3$ application. Gypsum increased exchangeable calcium levels in the soil and reduced any effects of the applied sodium. The exchangeable sodium level was raised by $NaHCO_3$ application alone. Gypsum treatment after $NaHCO_3$ application reduced exchangeable sodium to lower levels than measured in the control. Exchangeable magnesium and potassium levels were also reduced by gypsum application. However the effect was small and no benefit could be shown in yield or aluminium and manganese levels in petiole analyses (data not presented).

Table 2: Fertigation of sodium bicarbonate with surface applied gypsum at Mt Helen.

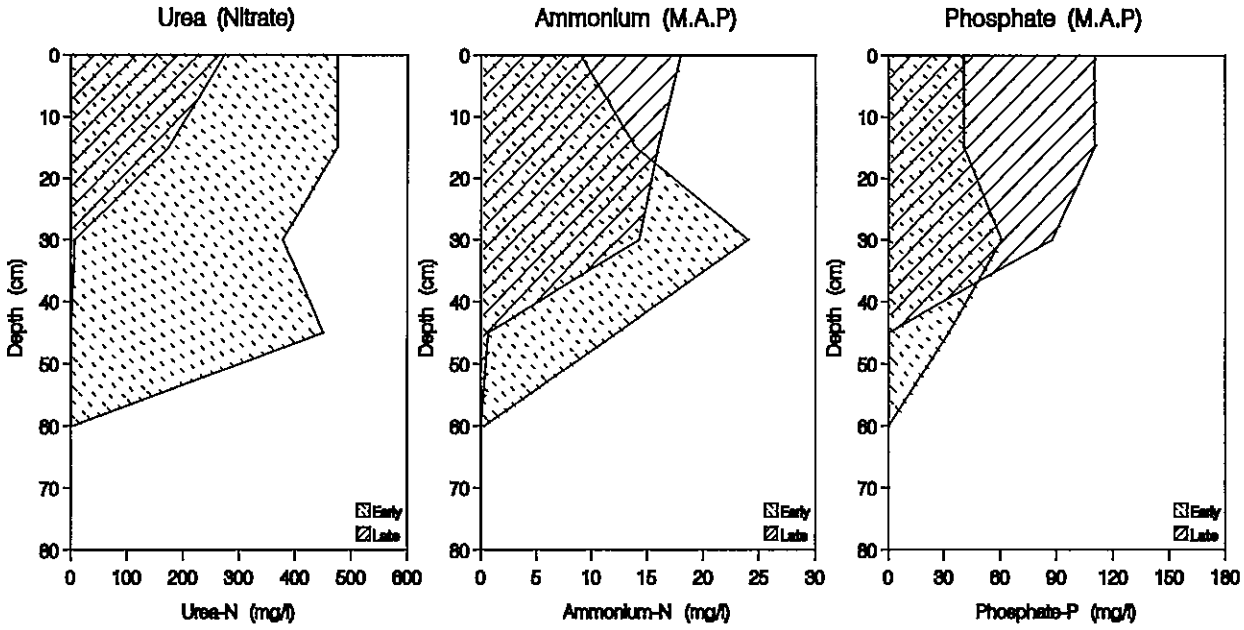
	Soil pH (0.01M $CaCl_2$)		Exch. Aluminium Mg/kg		Exch. Sodium Me/kg	
	Control	$NaHCO_3$/ Gypsum	Control	$NaHCO_3$/ Gypsum	Control	$NaHCO_3$/ Gypsum
0-10cm	4.60	5.59	34.7	13.1	1.36	1.02
10-20cm	4.34	5.19	86.6	11.4	1.18	0.90
20-30cm	4.19	4.73	121.9	27.8	1.61	0.80
30-40cm	4.08	4.46	193.4	103.7	1.33	1.51
40-50cm	4.06	4.28	302.7	216.2	2.55	1.98

Further experiments with fertigated $NaHCO_3$ showed that in slightly heavier soils no pH effect could be obtained below 20 cm. Given that the cost per unit of alkali is 15 times that of lime and its limited effectiveness, we concluded that this treatment was not practical.

2.3 Movement of nitrogen fertiliser in the wetting pattern.

A series of experiments investigating the movement of fertilisers and nutrients under micro irrigation were conducted. The results indicate that fertiliser and nutrient movement was a great deal quicker than previously thought. Mobile compounds such as urea and nitrate were readily leached to depths of sixty centimetres or greater in normal irrigation runtimes of 5 to 8 hours. A simple strategy of applying the fertiliser or fertigating in the last hour of the irrigation dramatically improved the distribution of fertiliser, with the majority kept in the topsoil (Fig 2).

Figure 2: Fertiliser movement under micro-irrigation.
Effect of applying fertiliser either Early or Late in a 5 hour irrigation run. The figure shows fertiliser levels in the soil solution estimated from suction tube samplers placed at 15 cm, 30 cm, 45 cm and 60 cm depths. The Early was applied in the first hour of irrigation and the Late was applied in the last hour of irrigation.



The movement of relatively immobile nutrients, such as ammonium and phosphorus, when applied from a soluble source such as MAP was significantly greater than expected. This could explain the rapid phosphorus responses observed by growers to MAP in the field. We do not however recommend the use of MAP in fertigation as it is a very acidifying fertiliser that will acidify the irrigated soil rapidly. Again the simple strategy of late application in an irrigation improved distribution and would reduce the potential of fertiliser leaching.

Conclusion

The program has made a number of findings that can be used by grape growers to improve fertilisation and importantly reduce soil acidification and the possibility of nutrient pollution.

- Test soil before planting vines. Ensure that soil tests adequately describe the depth and extent of acidify problems and that lime recommendations give adequate rates to amend pH to the required depth. Lime must be incorporated to the required depth to ensure optimal pH for new vines.

- If soil acidity problems are moderate and predominantly in the topsoil then surface applied lime will slowly raise soil pH in the topsoil. Surface applied lime has little effect on subsoil pH and on severely acidified soil.

- A nitrate based fertiliser such as calcium nitrate is the current best option for slowly raising soil pH in the irrigated root zone of acidified vineyards. The nitrate based fertilisers are very expensive per unit of nitrogen and cheaper options are available for non acidified plantings.

- If fertigating apply fertiliser late in the irrigation run or in a short run ensure that total irrigation runtimes are not excessive by the use of a simple augur or soil probe. Normal irrigation runtimes should also be non leaching, except when saline water is encountered.

- Care should be taken in selection of fertilisers. Fertiliser containing ammonium sources only (ammonium sulphate, MAP, etc) will acidify soil even if used efficiently. Urea, ammonium nitrate, etc will only acidify if used inefficiently. calcium nitrate and potassium nitrate will slowly increase soil pH if used efficiently, ie these should be applied late in the irrigation run using smaller but more frequent applications.

Appendix I

Refereed Papers

McNab S.C and Jerie P.H. 1988. Effects of potassium bicarbonate on soil acidity resulting from combined irrigation and urea fertilisation. Acta Horticulturae. 240, p 173-177.

Conference Papers

McNab S.C and Jerie P.H. 1989. Alkali amendment of soil acidity in a low flow irrigated vineyard. Proceedings Acid Soil Workshop, Coonawarra. October 1989, p 43-44.

Jerie P.H and McNab S.C. 1990. Soil acidification in trickle and microjet irrigated orchards. Proceedings Irrigated Horticulture Workshop, Orange NSW. October 1990, 3 pages.

McNab S.C, Jerie P.H and O'Connor R. 1991. Soil acidity and nitrogen fertilisers under low-flow irrigation. Proceedings of first National Conference Australian Society of Horticultural Science, Sydney NSW. October 1991, p 183-188.

Major Industry Articles and Reports

McNab S.C. 1989. Soil acidity problems with low-flow irrigation. Rural Quarterly, Vol. 2, No. 1. Autumn 1989, p 15.

McNab S.C and Jerie P.H. 1990. Soil acidity - What is it and how to handle the problem in a trickle or microjet irrigated orchard. Northern Victorian Fruitgrower, Vol. 14, No. 8. June 1990, 2 pages.

McNab S.C. 1990. Soil acidity and nitrogen fertilisers. Australian Grapegrower and Winemaker Annual Technical Issue, No. 316. April 1990, p 28-29.

McNab S.C and Jerie P.H. 1991. Soil acidity, nitrogen fertilisers and lime. The North East and Goulburn Valley Farmer. July 1991, p 18.

O'Connor R, McNab S.C and Jerie P.H. 1991. Soil acidity - Preventative measures are essential. Northern Victorian Fruitgrower, No. 18. September 1991, p 11-12.

O'Connor R, McNab S.C and Jerie P.H. 1992. Soil acidity and nitrogen fertilisers. Northern Victorian Fruitgrower, No. 16. April 1992, p 10-14.

McNab S.C. 1993. Efficient fertiliser application. Australian Grapegrower and Winemaker, No. 395. November 1993, p 45-50.

McNab S.C. 1994. Lime and soil acidity in the vineyard. Australian Grapegrower and Winemaker Annual Technical, No. 364. April 1994, 3 pages (accepted in press).

Major Seminars and Media Articles

McNab S.C. 1990. Soil acidification, nitrogen fertilisers and vineyards. Wine Industry Seminar D.A.R.A., Bendigo. June 1990.

McNab S.C. 1991. Soil acidity and nitrogen fertilisers and liming in the vineyard. Vineyard Soil Management Workshops, (3 Workshops) Tarrawarra, Mt Langi Ghiran and Milawa. November 1991.

McNab S.C. 1992. Soil acidity and nitrogen fertilisers in improving vineyard yield. Central Victorian Vineyard Association, (Seminar) Lancefield. February 1992.

McNab S.C. 1992. Efficient fertigation in the vineyard. Central Victorian Vineyard Association, (Seminar) Domaine Chandon. December 1992.