

## Reasons for the use, or otherwise, of soil and petiole nutrient testing by Australian wine grape growers

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**Abstract** Current wine industry best practice is for wine grape growers to base their fertiliser and nutrition management decisions on soil and petiole test results. Yet industry surveys have found that only a small proportion of growers regularly use these tests. In this qualitative study 45 wine grape growers from cool, warm and hot climate wine grape producing regions in southeast Australia were interviewed on their use of soil and petiole testing, in order to explain why, and when these growers used, or did not use, soil or petiole tests. We found that some growers only used soil or petiole testing once, seeking the benefit of accurate information to enable them to determine what nutrition inputs to incorporate into the soil when establishing a vineyard, or to enable them to diagnose a vineyard problem. Other growers used testing for one to four years (short-term use) “to get a handle” on a new vineyard or to evaluate changes in vineyard conditions or management. A few growers tested regularly on a continuing basis (long-term use) to monitor a problem, guide their fertiliser inputs or to ensure there were no nutrition problems arising (risk management). Some growers did not perceive that they needed the information provided by soil and petiole tests. These growers had extensive experience in growing vines, or had inherited established vineyards. They stated that they used the same nutrition program each year, were satisfied with the performance of their vines, and did not have any nutrition related problems.

**Keywords:** adoption, soil testing, petiole testing, nutrition, wine grapes, viticulture, Australia, market segments.

### Introduction

Grape vines must have access to adequate nutrition in order to grow a marketable wine grape crop (Robinson 1992; Singh 2006). Nutrient deficiency can lead to stunted vine growth and subsequent loss of yield (Robinson 1992; White 1997). Too much nutrition may cause excessive vine vigour and the appearance of toxicity symptoms, as well as unnecessary expense and the leaching of nutrients into the environment (Robinson 1992; White 1997; Singh 2006).

The most common way to determine the nutrient levels of vines or soils in vineyards is to conduct petiole (vine leaf stem) tests or soil tests, or both. Typically, petiole and soil samples are collected in vineyards by grape growers and submitted to a laboratory for analysis. Soil samples are analysed to determine micro-nutrient, macro-nutrient, pH and salt levels. Sometimes, depending on the service provider and service purchased, other characteristics such as organic matter content are also tested. Vine petioles are analysed to determine the micro-nutrient and macro-nutrients levels in the vine (Robinson 1992; Cooperative Research Centre for Viticulture 2006). The results of the tests are then compared with industry standards for grapevines (Swinburn and Saris 2005).

The Cooperative Research Centre for Viticulture and the Department of Primary Industries Victoria recommend as best practice that wine grape growers base their nutrition management decisions on the results of annual soil and petiole tests (Robinson 1992; McConnell et al. 2003; Cooperative Research Centre for Viticulture 2005). In a previous paper (Hill et al. 2009), we found that grape growers adopted nutrition-related products, primarily fertilisers and mulches, for two key reasons. The first was to optimise the establishment and growth of young grape vines. The second was to manage established vines to meet their vineyard production objectives. Overall, growers considered the nutrition-related products and practices that were available to be satisfactory for optimising the growth and establishment of young vines. Consequently, we concluded there was little need for research into new products in this area.

Growers reported that they experienced a number of nutrition-related problems in regard to their established vineyards. These problems concerned nutrient availability, soil health and modifying wine grape quality. However, despite these problems and in disregard of best practice recommendations, industry surveys have found that only a relatively small proportion of grape growers regularly used testing, even though between 50 and 75 per cent of grape growers had soil and petiole tests carried out at some stage (Hood et al. 2003; Swinburn and Saris 2005). Our purpose in this paper is to explain why and when wine grape growers used soil and petiole testing.

## Background

Growers test soil and leaf petioles because the resulting information offers some kind of benefit in their management of vines and vineyards. Presumably, differences in growers' use of soil and petiole testing result from differences in their perceptions of the management benefits from testing. Consequently, explaining differences in adoption of soil and petiole testing depends on identifying the benefits growers seek from the tests, and identifying the aspects of the farm context that influence the magnitude of these benefits.

A search of the literature did not reveal any published papers on the adoption of soil and petiole testing in viticulture. However, the adoption of soil testing has been studied in other agricultural industries (King and Rollins 1995; Contant and Korsching 1997; King 1999; Srivastava and Pandey 1999; Bewsell and Kaine 2001; Kremer et al. 2001; Napier and Tucker 2001; Yadav et al. 2006; Walton et al. 2008; and Fe`li et al. 2010). Generally speaking, these studies have found the adoption of soil testing was influenced by a variety of factors including: knowledge of soil sampling principles (Fe`li et al. 2010); timeliness and reliability of tests (Yadav et al. 2006); age, education level, size of farm and economic situation of the farmer (Contant and Korsching 1997; Kremer et al. 2001; Walton et al. 2008; Fe`li et al. 2010); and the type of communication used by, and attitudes of, extension agents (King and Rollins 1995; King 1999)

With the exception of farm size and the timeliness and reliability of tests these factors, by and large, are likely to influence the rate of adoption of soil testing rather than influencing the benefits or relative advantage soil testing might provide. Bewsell and Kaine (2001) investigated the use of soil testing by Victorian vegetable growers. They reported that the specific management benefits these vegetable growers sought from soil testing were to tailor crop fertiliser programs, to monitor nutrition problems, to identify and detect the emergence of new problems, and to manage product quality.

## Method

Many models of adoption have been proposed (Ajzen 1971; Rogers and Shoemaker 1971; Fishbein and Ajzen 1975; Bandura 1977; Chamala 1987; Davis 1989; Bagozzi 1992; Rogers 1995; Abadi Ghadim and Pannell 1999). These models vary in their complexity; the stages in the adoption process they distinguish, the sophistication with which they describe the processes at work in particular stages, and their generality. All of these models propose that the adoption of an innovation is a function of the producer's perception of the degree to which the innovation offers a relative advantage, that is, contributes to the achievement of their goals (Lindner 1987; Pannell 1999).

However, all these adoption models are constructed on the assumption that the elements in the producer's context that influence the extent to which an innovation promises a relative advantage can be identified using a process of discovery that is external to them. While some of these models offer extensive suggestions as to the various elements in the context that may influence decisions, they do not contain mechanisms for identifying precisely which elements are influential for a particular innovation. Consequently, these models of adoption cannot be used in isolation to identify the population of potential adopters of an innovation.

Kaine (2008) described a method, underpinned by concepts from consumer behaviour theory and farm systems theory, for analytically identifying the factors in a producer's context that influence the relative advantage offered by an agricultural technology or practice. The method has been applied to a variety of agricultural technologies and practices in a number of industries. In short, the adoption of soil or petiole testing by grape growers will depend on the extent to which growers believe these tests offer them a relative advantage. To identify the factors that influence grower's perception of the extent to which soil and petiole tests would offer a relative advantage we followed the method described in detail by Kaine (2008).

The method uses laddering (Grunert and Grunert 1995) and convergent interviewing, a dialectical process (Dick 1998) to similarities and differences in the reasoning underlying the decisions and actions of producers. Laddering is used in personal interviews with a producer to elicit the reasoning underpinning their decision to use, or not, the technology or practice of interest. Similarities in the reasoning of producers should result in similar decisions. Differences in decision-making by producers should be the logical product of differences in their reasoning. Producers are interviewed until the point is reached where the similarities and differences in the decisions of producers are reconciled with similarities and differences in their reasoning. This is the point of convergence (Kaine 2008).

The method described by Kaine (2008) can be applied, in principle, by interviewing a random sample of producers until convergence is reached. In practice, convergence can be achieved

more efficiently by interviewing a random sample of producers stratified on use or not of the technology or practice of interest, and factors that might reasonably be expected to influence the relative advantage of the technology or practice of interest such as enterprise location and size.

We conducted interviews with 45 grape growers from cool (Coonawarra, McLaren Vale, Padthaway, Yarra Valley and Wrattobully), warm (Barossa Valley, Bendigo, Goulburn Valley, Heathcote and Strathbogie Ranges) and hot (Sunraysia) wine grape producing regions. Growers were selected to represent large, medium, small, family and corporate businesses, and a cross section of wine quality grades and price points. This number of interviews was sufficient to achieve convergence.<sup>1</sup>

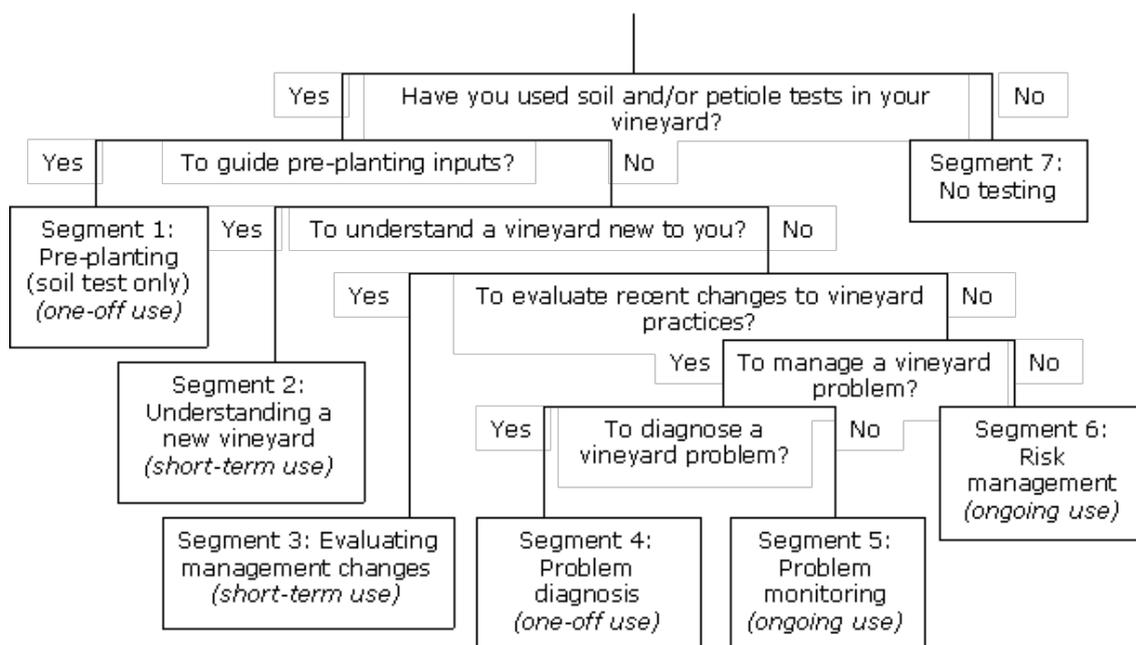
The interview data were transcribed manually with two interviewers participating in each interview. Following a dialectical process, the responses of interviewees were analysed and summarised using case and cross-case analysis as each interview (case) was completed (Patton 1990). Growers were classified into benefit segments for soil and petiole based on their reasoning for using testing, or not, as described next.

**Results and discussion**

The growers that used soil tests and petiole tests did so seeking a range of benefits. These benefits varied depending on a number of contextual factors, such as the age of the vineyard, and if the grower was seeking to evaluate management changes or to diagnose a problem, and provide the basis for classifying them into benefit segments (see Figure 1). The benefits sought influenced if the growers would use the tests only once, for a limited time, or as a long-term decision support tool. Interestingly, reducing the risk of nutrient losses to the environment did not emerge as a critical reason for regular use of soil and petiole testing. This suggests that efforts to promote regular soil and petiole testing on the grounds of environmental best practice are unlikely to meet with success.

It was possible for individual growers to be in two or more segments simultaneously depending on the nature of their vineyard. For example, a grower could be a member of segment 1 (soil test pre-planting) if they were establishing a new block in their vineyard, and at the same time, be a member of segment 6 (petiole test annually to monitor nutrition) for established blocks in their vineyard.

**Figure 1. Market segments based on the benefits sought by growers by soil and/or petiole testing**



<sup>1</sup> The data for this paper was collected during the interviews in which we collected the data analysed in Hill et al. (2009).

## **Description of benefit segments<sup>2</sup>**

### Segment 1: Soil test pre-planting

Almost all of the growers interviewed tested their soils prior to planting new vines. The benefit of this was to determine accurately the type and amount of inputs such as fertiliser, gypsum and lime they should incorporate, often by deep ripping, into the soil prior to planting. Incorporating the correct nutritional inputs was seen as important by these growers in order to optimise vine establishment and survival, and to minimise future nutrition related problems. Some growers who conducted pre-planting soil testing did not retest the soil again later.

Laura, a grower from the Strathbogie Ranges said:

*"I had the whole vineyard site soil tested before I planted. I wanted to make sure that I got the right amounts of lime, gypsum and superphosphate down the rip lines to give the vines a strong start. If you miss that chance you will run into problems later, and will always be trying to fix something up that you should have taken care of before".*

Most of the growers interviewed said that they were satisfied that the soil tests provided them with the information they needed in this regard. A few growers reported that they believed they had received incorrect recommendations, possibly because the test results had been misinterpreted.

### Segment 2: Understanding a new vineyard

Some growers used soil and petiole testing in the short-term to "get a handle on things", that is, to obtain information about a vineyard that was new or unfamiliar to them. The growers in this segment tended to use soil and petiole tests for one to four years, after which they said they understood the nutritional requirements of their vineyard and how their soil and vines responded to the fertilisers and products they were using. Testing over this period gave the growers the confidence that their nutrition program was working and they were not going to run into serious nutrition problems in the future.

Michael, a Bendigo grower, used petiole testing while he was new to the vineyard:

*"I've done petiole analysis in the past. It definitely helped us set our fertiliser program. We have got a handle on it now though. We were getting the same results all the time and the site has fairly well balanced vines, so it's not worth testing anymore".*

Tony is a Sunraysia grower, with vineyards on three different properties. Tony said:

*"I used to monitor the water and do soil and petiole testing. It gives you the information to make sound, informed decisions. But with falling grape prices and rising costs I don't do it anymore. The soil tests always came up good, and never identified any problems. I kept doing petiole tests until I saw the trends, and until I got a good handle on it. You need to combine science with experience to be successful".*

The growers in this segment said that testing provided them with the information they needed.

### Segment 3: Evaluating management changes

Growers in the segment describes as 'Evaluating management changes', also used soil and petiole testing for a limited period. The benefit of using testing for these growers was that it enabled them to evaluate and understand the impact of management changes they had made in their vineyard, either on the soil characteristics (soil test), the vines nutrition status (petiole testing), or both (soil and petiole test). Examples of the management changes they evaluated were using a new fertiliser, or changing the rate of a fertiliser, mulching, or installing drip irrigation. These growers used the tests for a few years until they felt that they "had a handle on things" and understood the implications of the changes they had made. They then ceased testing.

For example Bill, who has a vineyard in Sunraysia, told us:

*"When I installed drippers I had soil pits dug and the soil tested. I wanted to know if the new irrigation system would affect the nutrient availability of my soil. It turned out I've got uniform soils and changing to drippers didn't have enough effect (on nutrient availability) for me to need to change my fertiliser program".*

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<sup>2</sup> Names are fictional.

Hayden manages vineyards in the Coonawarra region. In recent years organic sprays, mulches and manures have been included in his nutrition program and he was interested to know if these changes had improved soil health and nutrient status. Hayden said:

*"We are trying to go for softer options now, conventional (fertilisers) are not as good for soil, they kill off the bacteria and fungi in soil, which damages the soil structure and reduces nutrient uptake. I will do a soil test this year which will include a biological test because I haven't done one for a while and I want to know if these (organic) products are helping".*

Growers in this segment had not experienced any problems with soil and petiole testing.

#### Segment 4: Problem diagnosis

Growers in the 'Problem diagnosis' segment used the tests to try to determine why vines were looking unhealthy or weak, for example if vine growth was sparse or the leaves were discoloured. These growers said that when they found unhealthy vines, they first checked the vines' roots for damage and then conducted soil and petiole tests to determine if the cause was nutrient or soil related.

For instance Chas, who grows vines in the Goulburn Valley, said:

*"I had a soil test done because I had a problem in the vineyard and was trying to rule out a number of possibilities. I'd looked at the roots, water, soil and weeds, but there was no problem with these so I thought I'd better look at nutrition. I tested an area of healthy and an area of sick vines and the tests results all looked the same. This made me realise it may be a pest issue. It turned out that the sick vines were infested with phylloxera".*

Dave grows red wine varieties in the Barossa Valley, Dave said:

*"If I see an issue with my vines I get a petiole test done. I tested some Shiraz five years ago, the test showed the vines had a boron deficiency. I had a feeling that was the problem because the vines looked so ordinary. The test confirmed that that was the problem".*

The benefit growers in this segment sought from soil and petiole testing was identification of the cause of their vine health problem. If the problem was nutrition related, the growers then wanted to know which fertiliser or soil treatments would effectively solve the problem. Growers in this segment observed that the benefits they sought from soil or petiole testing were not realised if:

- There was more than one factor causing the problem with vines.
- The cause was related to nutrition, but the vines were not flowering, so petiole testing could not be conducted.
- The test recommendations were inaccurate, incorrect or not suited to the site.

#### **Discussion on one-off and short-term use of testing**

The growers in Segment 1 and Segment 4 used soil and petiole tests once. These findings are consistent with those of Bewsell and Kaine (2001) who found that some vegetable growers only conducted soil tests when planting on a new block of land.

Growers in Segment 2 and Segment 3 used the tests in the short-term (one to four years) to enable them to "get a handle on things" when managing a new or unfamiliar vineyard or evaluating management changes. These growers were satisfied that the tests had helped them achieve that. Bewsell and Kaine (2003) found that grape growers in New Zealand used soil moisture monitoring for some years until they were confident with their vineyard irrigation and soil. Like the wine grape growers in Segment 2 and Segment 3, the New Zealand growers ceased using the technology when they felt they "had a handle on it".

The growers in segments 1, 2, 3 and 4 have used testing to resolve a problem with production. They then cease testing because they do not perceive any further benefit to be had from testing. In effect, the growers in these segments are likely to become members of segment 7 once they discontinue testing. Conversely, under the right conditions, growers in segment 7 are likely to be, or become, members of any or all of segments 1, 2, 3, or 4. There is then, an exchange of members between segments 1, 2, 3, 4, and 7.

Kremer et al. (2001) found a similar pattern in the adoption and use of the N-track self-administer soil nitrogen test amongst Iowan farmers who initially adopted the technology then discontinued use after a few years. These farmers perceived that the N-track had enabled them to obtain a good understanding of their crop nitrogen requirements.

The short-term use of the tests does not represent a failure of the technology, but rather demonstrates that use of the tests had provided the information the growers required. Once the growers' information needs had been met, the cost of further testing outweighed the benefits received and hence the grower ceased using the tests. The growers from these segments said they would use soil or petiole testing again if they were to experience a nutrition problem in the future. This has two important implications from an extension perspective.

The first implication is that the appeal of extension messages promoting the use of soil and petiole testing could be broadened if messages included content highlighting the benefit of testing when establishing new vines and testing to diagnose and resolve problems with vine health (e.g. McConnell et al. 2003).

The second implication concerns the value of promoting the regular use of soil and petiole as a best management practice to improve productivity. That growers used soil and petiole testing to meet a short-term need but then abandoned it, suggests that most growers possess the knowledge and skills to successfully adopt and implement the testing technology.

Consequently, the failure of growers in segments 1, 2, 3 or 4 to use the technology cannot be attributed to some lack in their appreciation of, or capacity to implement, soil and petiole testing. It seems reasonable to presume that, had they experienced substantial reductions in grape yield or quality once they discontinued testing, these growers would have resumed regular testing. In other words, the failure of the growers in these segments to continue regular testing suggests that, once they had stopped testing, they did not detect a decline in grape yield and quality sufficient to convince them that it would be worthwhile to resume testing. The experience of these growers is, then, that regular soil and petiole testing is not worthwhile for mature vines in good health.

Therefore, growers who test once, or for a short time only will be unlikely to respond to extension messages seeking to promote regular testing as best management practice for productivity. Such messages contradict their experience. At best, they will disregard such messages, regarding them as not relevant to their circumstance, unless it can be demonstrated that continued testing would generate a substantial improvement in production performance of mature vines. Such messages could cause growers to question the credibility of the source of these messages.

#### Segment 5: Problem monitoring

Growers in the 'Problem monitoring' segment regularly used soil and petiole tests to monitor a long-term problem they were experiencing (such as soil salinity or nutrient deficiencies), or a situation they believed could develop into a problem (such as acidity levels). The growers in this segment indicated that they had identified the source of the nutrient imbalance, hence they were not members of Segment 4, and while they may be adjusting their fertiliser program to address the nutrient imbalance, they were not planning major management changes (Segment 3).

An example of a grower in this segment was Sarah who manages a Coonawarra vineyard. Sarah said:

*"We are worried about our soil salinity levels, so we soil test regularly. We also use soil tests in problem areas to confirm petiole test results, which we conduct every year. We use petiole tests mostly because they have standards and they give us a better indication of what the plant has taken up, rather than what is there (in soil) but not available. We just want to make sure things are not getting out of hand".*

#### Segment 6: Risk management

Growers in the 'Risk management' segment had tests done regularly to monitor conditions in their vineyard, even though they do not have any significant soil- or nutrition-related problems. The growers said that the benefits of doing this were that they had peace of mind that their vines' nutrition needs were being met, that their production goals (yield and quality) would be achieved, and that they would not be caught unprepared by any nutrition related problems. Other growers in this segment used soil and petiole test results when liaising with vineyard owners, chief viticulturists, finance managers or wineries about grape quality, vineyard planning or management or budgets. Essentially an unexpected nutrition problem poses a major risk for these growers and soil or petiole testing can easily and inexpensively manage this risk.

Kingsley runs a vineyard in Heathcote. Kingsley told us:

*"We base our rate of fertiliser application on soil and petiole tests, and test nine out of seventeen blocks each year. In April we soil test and put out any necessary*

*ameliorations we need to meet our production targets. The test results enable me to convince the finance people we're doing the right thing, and get the fertiliser allowance we need".*

### **Discussion on long-term use of testing**

The growers in Segment 5 and Segment 6 used soil or petiole testing regularly for long periods, which is recommended best practice, and said they found the information valuable in enabling them to monitor problems or manage production risks. Likewise, Bewsell and Kaine (2001) reported that some Victorian vegetable growers used soil testing regularly to determine the nutrient status of their soil and tailor crop fertiliser programs accordingly, or to monitor nutrition problems. They found that soil moisture monitoring was regularly used by wine grape, fruit and vegetable growers to identify and detect the emergence of new problems, to monitor existing problems, and to manage product quality (Bewsell and Kaine 2001, 2003; Kaine and Bewsell 2001a, 2001b; Kaine et al. 2005).

The implication of this behaviour is that, unlike the growers in the other segments, growers that regularly use testing view the costs of regular testing as less than the anticipated costs of correcting any nutrient-related problems in production that might appear in the future. However if these growers start to perceive that the cost outweighs the benefit gained through testing, they will cease testing. This may be due to the emergence of a new technology or service that provides the information they require more quickly, cheaply or efficiently, or the problem they are monitoring or risk they are managing may dwindle in importance.

### **Segment 7: No testing**

The growers in 'No testing' segment had not used soil or petiole testing and had either inherited established vineyards or had extensive experience in growing vines in their vineyard. These growers said that they used the same nutrition program each year, and, if any problems had occurred, they had been able to identify the cause of the problem and solve it. Consequently, they may, at an earlier time, have been members of segments four or five. The growers in this segment were satisfied with the performance of their vineyards and said they did not require the information soil and petiole tests would provide.

Angelo is a Sunraysia grower of both wine and dried fruit grapes. Angelo said:

*"I don't soil or petiole test, I just look at the vines. If the vines start to look poor I fertilise with nitrogen. I don't seem to have any soil or nutrition problems, the vines usually look fine".*

Another example of a grower in this segment was Bill who has been growing wine grapes in the Barossa valley for many years. Bill said:

*"My grandfather started this vineyard in the 1920s, then my father ran it and I've run it for the last 25 years. If the cover crop looks healthy then I assume the nutrients are all right. Our Shiraz is close to top of the range so there is no reason to mess with that".*

These growers appeared to believe that soil and petiole testing was not worthwhile for mature vines in good health. Therefore, these growers will be unlikely to respond to extension messages seeking to promote regular soil and petiole testing as best management practice to improve productivity, unless the benefits can be demonstrated to them. However, if their vineyard developed a nutrition-related problem or perhaps they made management changes such as starting to mulch their vines, these growers may decide that testing would provide worthwhile information and may experiment with, or begin to use soil and petiole testing.

### **Conclusion and future work**

Soil and petiole tests were widely used by wine grape growers when making vineyard nutrition and soil management decisions. However, only a small proportion of growers followed best practice and regularly tested on a continuing basis. We have described the reasons why this is the case.

Further research involving surveying a large sample of grape growers would be useful to quantify the numbers of growers in the segments, and statistically validate the results and conclusions reported here.

Efforts to promote regular soil and petiole testing as environmental best practice to wine grape growers may be successful. Success will depend on the extent to which each grower is concerned about nutrient losses through leaching and run-off in their vineyards and wish to minimise their use of fertilisers and if the growers regard, or can be convinced, that soil and

petiole testing as useful tools in achieving this. It would require further social research to determine growers' attitudes about this topic.

The use of other available agronomic tests, such as sap testing or leaf blade analysis could be investigated in the future to determine why the use of these tests is not more widespread. The existence of patterns in the reasons for using management tools, such as soil and petiole tests and soil moisture monitoring, across horticultural and other agricultural industries may be worth further research.

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