MULCH
FOR SUSTAINABLE PRODUCTION

HortResearch

MARLBOROUGH DISTRICT COUNCIL

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Designed by:
Vivienne Laursen of Little Bonsai Design, Blenheim, Marlborough

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MULCH
FOR SUSTAINABLE PRODUCTION

Compiled by:
Rob Agnew and Dion Mundy
HortResearch Marlborough

Mike Spiers
Hort Research Ruakura

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EXECUTIVE SUMMARY

With huge areas of grapes being planted in Marlborough and a number of other regions, sustainable management practices need to be introduced to alleviate the results of monocultural production over long periods of time.

It was identified that one way to improve the sustainability of winegrape production was to incorporate vineyard and winery waste into mulches for use in vineyards, rather than dumping it off-site. From the Marlborough community perspective a number of other waste products were identified that could potentially be utilised in mulches. These included green waste from the municipal authority, bark from pine forestry operations, animal manure from stockyards and shells from green lipped mussel processing.

This booklet contains a summary of three years of research under Marlborough conditions.

The experiments conducted in this project were aimed at identifying whether using mulch is an option for sustainable production. The mulch project was designed to investigate a number of parameters that mulching might affect including possible problems with mulching as well as the advantages.

The key benefits from using mulches that were identified included:

- soil moisture retention enabling a reduction in irrigation
- nutrient release enabling a reduction in fertiliser application
- weed suppression enabling a reduction in herbicide usage
- increases in yeast available nitrogen in grape juice

Other positive effects measured were soil organic matter increases, soil temperature buffering and increases in soil fungi population.

Mulching did not increase frost risk, or increase disease risk. No significant and consistent changes were detected in pruning weights, juice Brix, yield, petiole or leaf nutrient content, induced resistance, and worm populations as a result of using mulch.

The practical considerations for the use of mulch in a vineyard are detailed in the second section of this booklet. These considerations include: the desirable properties of mulch, composting, statutory requirements when making mulch, estimated costs associated with making mulch, quantities of potential mulch materials available, comparative cost of purchasing or making mulch, nutrient composition and potential cost savings from using mulch.

It is the aim of this booklet to provide grapegrowers with information that will help them to make decisions regarding the use of mulch as a management tool in viticulture.

The use of mulch as part of sustainable vineyard management has the potential to enhance the brand positioning statement of New Zealand Winegrowers: *New Zealand Wine - the riches of a clean green land.*

KEY OUTCOMES FOR
SOIL

The numbers associated with the key outcomes are linked directly to the section numbers.

1. Mulch helped retain soil moisture early in the season.
2. Mulch released a number of nutrients into the soil for use by the grapevines.
3. Water infiltration rate was highly variable but appeared to decrease at one site with very stony soils.
4. Bulk density of heavier soil decreased slightly.
5. Soil temperature was buffered with the use of mulch, resulting in a more constant soil temperature around the roots of the grapevines.
6. Beneficial soil fungi populations increased positively over three seasons.
7. The use of mulched prunings did not increase the botrytis inoculum present in the vineyard.
8. Weed growth was suppressed under the mulched strip thus reducing herbicide use.
9. Worm populations did not increase under the environmental conditions experienced in Marlborough during the research project.
10. Mulch height decreased rapidly over the first year due to compaction and thereafter mainly by decomposition.

KEY OUTCOMES FOR
GRAPEVINES

11. Some increase in the activity of induced resistance enzymes was detected. No link could be made with lower disease levels due to low disease pressure.
12. Uptake of nutrients from mulch by the grapevines was most noticeable in the grape petioles. It appeared that the level of nutrient uptake was largely governed by the amount of spring rainfall.
13. There was not a marked increase in leaf nutrients even when soil levels were high, which suggests that grape leaves regulate the uptake of nutrients.
14. Mulch had no significant effect on the yield of grapevines
15. Juice soluble solids and titratable acidity were not affected by the use of mulch. Some small increases in juice pH were observed.
16. Application of under vine mulches had a positive effect on increasing yeast available nitrogen (YAN) in the grape juice where it was low.
17. Juice potassium levels increased slightly with the use of mulch.
18. The use of mulch did not increase the amount of Botrytis bunch rot on grapes and some indication of a possible reduction was observed.
19. The use of mulch caused a slight increase in the vegetative growth of grapevines. However seasonal variation was far greater than the variation between mulch and no mulch.
20. Pruning weights were affected more by site management practice than by mulch treatment.
21. The use of under vine mulch did not reduce grape canopy air temperatures and thus the frost risk to the grapevines did not increase.

CONTENTS

INTRODUCTION

In 1996, many changes were taking place in Marlborough. The Marlborough District Council was building a new landfill and transfer stations and Marlborough's major industries - viticulture, mussels and forestry, were beginning to grow at a fast rate.

A new solid waste management strategy was developed reflecting the Regional Policy statement.

One of the aims of the Regional Policy statement is:

"To support research into the alternative methods of waste minimisation and disposal in Marlborough, working with primary production activities. The content of many wastes could be made available as nutrients for primary production systems."

Community concerns were raised about the development of industries that may have effects on the community at large. Many of the by-products of those industries have potential as raw materials for the production of compost. The new landfill would not accept many of these products so other options were needed. The concept was put forward to utilise these by-products for mulch that could be used in viticulture.

The viticulture industry is proactive in looking for sustainable solutions, and had already taken up the Sustainable Winegrowing New Zealand programme. One of the elements of this programme was a change from calendar to target-based spraying.

Other industries were looking at ways to reuse their by-products.

It was decided to combine a group of experts to trial mulches in vineyards with the aim of retaining moisture, reducing spray usage and improving soil and plant health. If any of these aims were successful then the community would also benefit.

It was also clear that a detailed scientific study was needed. Overseas studies showed that mulches were effective, but there was no detailed New Zealand evidence.

An application to the Ministry for the Environment Sustainable Management Fund was made in 1997 and accepted with a request for further industry support.

With the science expertise of HortResearch staff, commitment from the Marlborough Research Centre, and support from Council, four major wine companies took up the challenge to trial and monitor mulches on their vineyards. Ten wine companies also made significant contributions to the programme and the Marlborough Grape Growers' Association saw it as a major project worthy of their support. Assisted by two forward thinking local contractors, Crafar and Crouch Construction Ltd., and Rose Agricultural Ltd., the field trials began in January 1999.

TRIAL METHODS

Field trials were established at four Marlborough vineyard sites in January 1999 using grafted Sauvignon Blanc vines that were at least five years old. All the vines were grown on commercial properties with the same vineyard management practises for the trial area as applied to the rest of the vineyard. The major difference between the four sites was in soil types. Some differences in leaf plucking, irrigation timing and other management practices also existed.

The trial was undertaken at four sites to show what influence mulch would have within a site under the differing vineyard conditions. It was not the intention of these trials to make direct comparisons between the four vineyard sites.

The texture of the topsoil was described by the feel procedure (USDA - Soil Quality Test Kit Guide 1998). Texture of the soil at the four sites was described as: site 1 - silty clay, site 2 - silty clay loam to sandy clay loam, site 3 - sandy clay loam, site 4 - clay loam. Sites 1 & 2 were deeper soils and sites 3 & 4 were dominated by large stones both on the surface and throughout the profile.

The trials at each site involved four mulch treatments, applied in January 1999, compared to an unmulched control. Each treatment was replicated six times and each replicate was in a single row of grapes, i.e. five treatments (four mulch + one unmulched) randomly arranged in a row and repeated in six rows, side by side. Trial plots at different sites ranged from 5.5 to 7.5 m in length and contained three or four grapevines, depending on the site. There were 30 plots at each trial site in a randomised block design.

Different waste streams were used to produce four mulches (Table 1), with carbon/nitrogen ratios around 25. The mulch treatments were applied at a thickness of 15 cm, in a 75 cm wide strip under the vines with no replenishment during the trial.

Table 1. Overview of treatments showing the percentage (by volume) of waste stream components in each mulch treatment

	Bare Soil Control	Mulch 1	Mulch 2	Mulch 3	Mulch 4
			Content by volume		
Vineyard prunings		36%	27%	25%	23%
Marc (grape pressings)		18%	13%	12%	12%
Green waste		46%	34%	32%	30%
Pine bark			26%	25%	23%
Animal manure				6%	6%
Mussel shells					6%

During the 1999/2000 season all trial sites received a standard fungicide spray programme, which included botryticides. On request, no botryticides were applied during the 2000/2001 or 2001/2002 growing seasons in order to determine whether the use of mulch had a suppressive effect on bunch botrytis.

RESULTS

1

SOIL MOISTURE RETENTION

Over the three years, soil moisture was monitored using Time Domain Reflectometry (TDR) at each of the four trial sites. Moisture was monitored over four depths in the soil profile: 0-15cm, 0-30cm, 0-45cm and 0-60cm. All four sites used existing drip line irrigation and standard irrigation scheduling during the mulch trial period. The vineyards were irrigated according to the requirements of the bare soil control plots. Data presented in figure 1 is from the dry zone away from the drippers and compares the soil moisture under the mulch with that of bare soil.

Soil moisture levels during the trial period were markedly different between the three seasons due to large differences in rainfall (Table 2). November 1999 recorded the highest ever November rainfall. November 2000 saw the start of the most severe medium term drought that Marlborough has ever experienced. This drought lasted 11 months until September 2001. From October 2001 to January 2002 was a period of high rainfall followed by a further four dry months from February to May 2002.

Soil moisture retention under mulch was most evident at site 1. At the other sites, with lighter soils, the results were more variable.

Moisture was generally higher under mulch in the upper part of the soil profile. Figure 1 shows how the soil moisture remained higher under mulch at site 1 in the early part of the 2000/2001 season. Comparing similar soil moisture levels early in the season for unmulched and mulched soils shows that the decline in soil moisture under mulch was delayed by up to six weeks.

By the beginning of January 2001 the moisture had declined to a minimum level in both unmulched and mulched plots. Moisture rose gradually under mulch during the winter of 2001 to a peak in the middle of August. With little rain at the start of the 2001/2002 season moisture declined rapidly in the bare soil plots, whereas in the mulched plots soil moisture was retained. The higher soil moisture under mulch was retained throughout the 2001/2002 season.

Table 2. Blenheim annual rainfall over the duration of the trial

Blenheim rainfall	(mm)
July 1999 – June 2000	747
July 2000 – June 2001	393
July 2001 – June 2002	752
Long-term average	647

MULCH HELPED RETAIN SOIL MOISTURE EARLY IN THE SEASON AND PROVIDED AN OPPORTUNITY FOR A DELAY IN THE ONSET OF IRRIGATION.

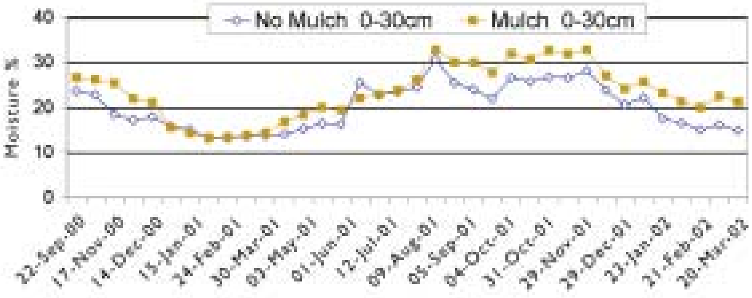


Figure 1. Soil moisture at site 1 where moisture retention under mulch was most evident

2

NUTRIENT RELEASE FROM MULCH AND THE EFFECT ON SOIL NUTRIENT LEVELS

Soil nutrients

Soil sampling of the mulch treatments was conducted over three years. The first soil sample was conducted in February 1999 prior to the application of the mulch (Table 3 - Pre mulch). This sample gave a base-line value for the various treatments. Further samples were conducted in November 2000 and November 2001. Soil samples were taken using a standard soil corer to a depth of 15 cm, or in the stony soils using a trowel. Ten soil cores were collected per replicate plot and combined to create a single soil sample. Soil samples were collected from four of six replicates for each of the five treatments (four mulched, one unmulched) for the four sites, giving 80 soil samples per year. Soil samples were limited to four of the six replicates in order to reduce costs. Soil analysis was conducted by Hill Laboratories Ltd.

Table 3 presents the soil analyses from the mulched plots over the three years. The bare soil control plots were also analysed, however these showed little change over the three years.

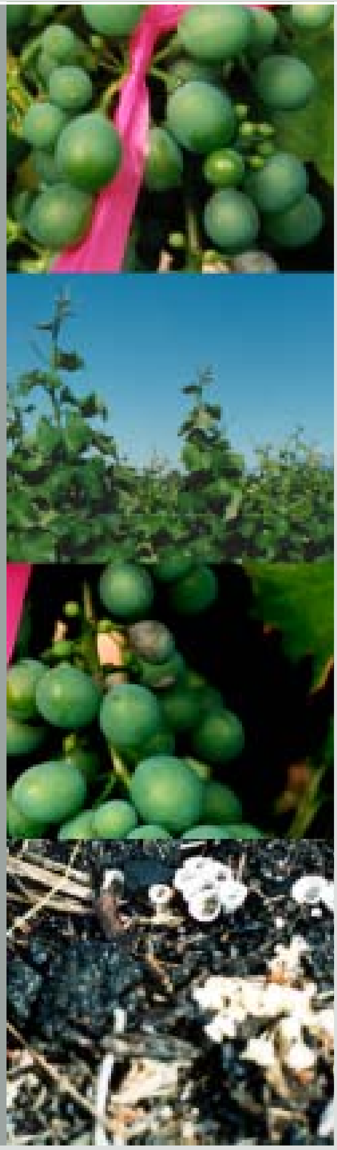


Table 3. **Soil analyses of mulch treatments 1-4 averaged**

Site	Year	Trt	pH ug/ml	P me/100g	K me/100g	Ca me/100g	Mg me/100g	Na me/100g	OM* %	CEC* me/100g	BS* %	VW* g/ml
Site 1	1999	Pre Mulch	6.06	19.13	0.41	7.16	1.07	0.09	3.58	12.14	71.81	1.07
	2000	Mulch	6.51	23.31	1.67	7.72	1.55	0.19	3.66	14.08	78.63	0.96
	2001	Mulch	6.09	20.31	1.55	9.45	2.02	0.33	3.78	17.95	65.06	0.92
Site 2	1999	Pre Mulch	6.51	10.00	0.43	7.24	0.90	0.06	2.68	9.56	90.31	1.11
	2000	Mulch	7.15	39.06	2.40	7.33	0.97	0.09	2.88	11.39	94.75	1.01
	2001	Mulch	7.09	28.06	1.81	7.51	1.07	0.08	2.86	11.43	92.50	0.98
Site 3	1999	Pre Mulch	6.04	24.19	0.60	6.44	1.19	0.08	4.19	11.71	70.63	1.02
	2000	Mulch	6.67	63.94	2.52	6.77	1.32	0.11	4.67	13.02	81.63	1.02
	2001	Mulch	6.64	53.50	2.28	6.43	1.30	0.12	4.46	12.50	80.44	0.99
Site 4	1999	Pre Mulch	5.18	47.50	0.68	6.06	0.85	0.05	5.70	16.41	46.63	0.97
	2000	Mulch	5.80	60.94	2.35	6.33	1.07	0.11	6.36	17.59	55.88	0.94
	2001	Mulch	5.84	59.50	2.27	6.64	1.28	0.11	6.80	16.78	60.94	0.98
Normal Range			5.6-6.8	30-80	0.5-1	6-12	1-3	0-0.5		12-25		1.0

* OM - organic matter, CEC - cation exchange capacity, BS - base saturation, VW - volume weight

The overall changes in soil nutrient status over the duration of the trial are presented in Table 4. They have been calculated by taking into account the differences between the mulch from 1999 to 2001, and subtracting the difference in the no mulch control from 1999 to 2001.

Table 4. Overall change in soil nutrient status from 1999 to 2001 due to the addition of mulch

Site	pH ug/ml	P me/100g	K me/100g	Ca me/100g	Mg me/100g	Na me/100g	OM* %	CEC* me/100g	BS* %	VW* g/ml
Site 1	6.06	19.13	0.41	7.16	1.07	0.09	3.58	12.14	71.81	1.07
Site 2	6.51	10.00	0.43	7.24	0.90	0.06	2.68	9.56	90.31	1.11
Site 3	6.04	24.19	0.60	6.44	1.19	0.08	4.19	11.71	70.63	1.02
Site 4	5.18	47.50	0.68	6.06	0.85	0.05	5.70	16.41	46.63	0.97

The changes observed in soil analyses between 1999 and 2001 can be summarised as:

- pH showed an initial large increase after the first year (2000). However, after the second year (2001), the pH decreased slightly. There was an overall increase in pH at sites 2, 3 and 4. At site 1 the pH remained similar to the initial value.

- Phosphorus (P) increased only moderately at site 1 in the first year and dramatically at the other three sites. However, in the second year phosphorus levels dropped. indicating little more was released by the mulch.

- Potassium (K) levels increased dramatically in the first year. However they dropped from the first year increase in the second year, though still remaining much higher than in the unmulched treatment.

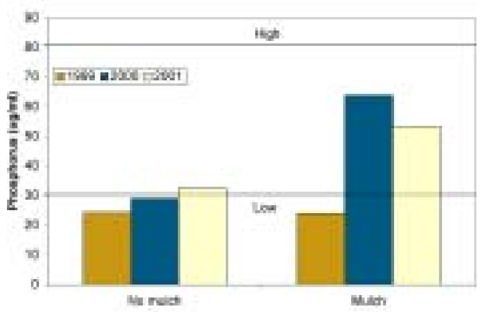


Figure 2

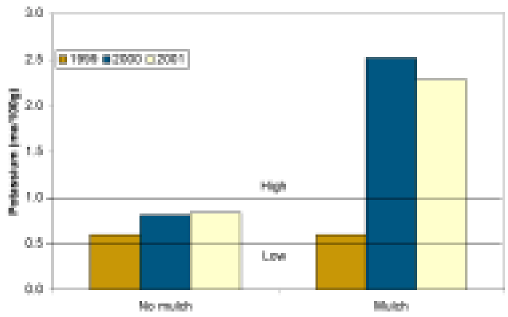


Figure 3

Figures 2 and 3. Changes in soil phosphorus and potassium at site 3 from 1999 to 2001. 1999 was prior to mulch application, 2000 and 2001 subsequent to mulch application. Changes at site 3 are indicative of the changes at all sites.

- Calcium (Ca) increased at sites 1, 2 and 4 but decreased at site 3.
- Magnesium (Mg) increased at sites 1, 3 and 4 but remained unchanged at site 2.
- Sodium (Na) showed marginal increases at all four sites.
- Organic matter showed a substantial increase at site 4 over the trial period. The fact that this increase was not seen at the other 3 sites is difficult to understand.

When considering the changes in soil nutrient status that took place it is important to remember that for the period November 2000 until October 2001 Marlborough suffered a severe drought. This is likely to have influenced the changes, with fewer nutrients being released from the mulch, especially since during this period a number of the soil nutrients and pH showed a decrease.

THE MULCHES APPLIED RELEASED CONSIDERABLE QUANTITIES OF NUTRIENTS INTO THE SOIL, WHICH WERE AVAILABLE FOR USE BY THE GRAPEVINES.

3

WATER INFILTRATION RATE

Water infiltration rates were measured at each site in August 1999 and again in June 2002. Mulch was removed from a small area of the soil surface. A steel ring measuring 15.7 cm in diameter was hammered into the soil to a depth of 7.5 cm (if it would go that deep before hitting stones). The ring was then lined with plastic and 492 ml of water tipped in (the equivalent of 1 inch deep). The plastic was removed and the amount of time taken for the water to infiltrate the soil was recorded. This test was repeated twice for each location of the steel ring. The moisture content of the soil affects the rate of infiltration. The first lot of water wets the soil, the second gives a better indication of the infiltration rate of the soil.

The method used for water infiltration rate and bulk density was obtained from the US Department of Agriculture publication "Soil Quality Test Kit Guide". This can be downloaded from the USDA web site at http:/soils.usda.gov.sqi/kit2.html

Water infiltration rate is a measure of how fast water enters the soil. Water entering too slowly may lead to ponding on level ground. Water entering very rapidly can be partly due to low levels of organic matter.

Infiltration rates were highly variable within and between sites (Table 5). The level of soil compaction strongly influences the water infiltration rate. The comparison between the four sites indicates that sites with heavier soils (sites 1 and 2) have lower infiltration rates and the stonier sites (sites 3 and 4) much faster infiltration rates. We have no explanation for the large changes in infiltration rate of the unmulched plots over the three-year period.

Table 5. Water infiltration rates measured in 1999 and 2001

	Water Infiltration Rate (mm/hour)							
	Site 1		Site 2		Site 3		Site 4	
	1999	2002	1999	2002	1999	2002	1999	2002
Mulch Mean	206	476	110	211	637	236	1023	1157
No Mulch	155	834	64	140	527	242	1677	756

Due to the extremely variable results it is difficult to draw any definite conclusions.

It was expected that adding organic matter to stony, free draining soil would decrease the infiltration rate. At Site 3 which was very stony, this appears to have been the case, even if the variation in the unmulched plots is taken into account. However Site 4, which was also very stony, gave extremely variable results.

At none of the sites was the infiltration rate low enough as to impede drainage or to make application of irrigation water difficult.

WATER INFILTRATION RATES VARIED GREATLY BOTH WITHIN AND BETWEEN SITES. OVER TIME THE USE OF MULCH SHOULD SLOW THE PASSAGE OF WATER THROUGH VERY STONY SOILS DUE TO INCREASING LEVELS OF ORGANIC MATTER.

4

BULK DENSITY

Bulk density of the soil was measured at the same time as water infiltration rate. The method used was adapted for the very stony sites. It involved digging a hole to 15-18 cm depth and 15 cm square, extracting all the contents, lining the hole with plastic and calculating the volume of the hole by filling with water. All the material extracted was weighed wet, dried, sieved to separate stones and then the dry soil and stones were weighed. The volume of the stones was calculated and subtracted from the volume of the hole.

Bulk Density measures the weight of soil for a given volume, and is an indicator of soil compaction. In general, the greater the density, the less pore space for water and air movement, root growth and penetration.

The soil type has a large influence on bulk density. Those sites with heavier soils (site 1 and 2) generally had higher bulk densities than those sites with stony soils (excluding the stones), (sites 3 and 4), (Table 6).

Ideally the soil bulk density for a sandy loam or clay loam should be less than 1.40 in order that root growth is unrestricted. The bulk densities recorded at all of the sites were not high enough to cause any problems with root growth.

Table 6 indicates that the bulk densities of the mulched plots at sites 1 and 2 decreased slightly over the three years, whereas at sites 3 and 4 there was virtually no change. This is in line with expectations that an increase in organic matter in a heavier soil type would reduce the compaction and therefore reduce the bulk density. However it is difficult to explain, given that at sites 1 and 2 there was little change in organic matter.

Table 6. Change in soil bulk density between 1999 and 2001

	Soil bulk density (g/cm^3)							
	Site 1		Site 2		Site 3		Site 4	
	1999	2002	1999	2002	1999	2002	1999	2002
Mulch Mean	1.334	0.985	1.499	1.333	1.246	1.325	1.002	1.036
	-0.349		-0.166		+0.079		+0.034	

BULK DENSITY OF HEAVIER SOILS DECREASED SLIGHTLY.

5

SOIL TEMPERATURE, ROOT DEVELOPMENT AND DATE OF BUDBURST

Soil temperature at a depth of 10 cm, in an unirrigated zone, was measured in bare soil and under mulch at Sites 2 and 3. Figure 4 shows the maximum and minimum daily soil temperatures at 10 cm depth, with and without mulch. The graph shows that the daily temperature over winter in bare soil fluctuated by up to 10°C, whereas the daily soil temperature in soil covered by mulch varied by less than 0.5°C. Over the summer the daily fluctuations in the bare soil were up to 13°C, whereas in the mulched soil the temperature fluctuation was within 1.5°C.

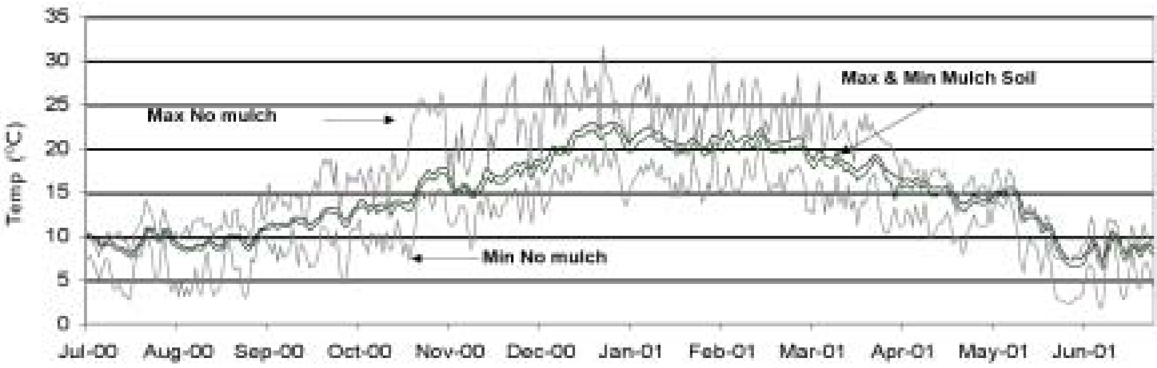


Figure 4. Soil temperatures at 10 cm depth - Site 2

Mulch obviously acts as a buffer for soil temperature. The maximum daily temperature in the bare soil at 10 cm depth on occasions exceeded 30°C. We would assume that as a consequence of using mulch that the shallow plant roots are subject to less stress. However, no measurements of plant stress were conducted as part of these trials.

Plant Roots

There has been a perception by some grapegrowers that the use of mulch encourages grapevines to develop surface roots and that this is an undesirable side effect of the use of mulch. The perception was that the plants will not develop deeper roots.

The effects of mulch on the roots of grapevines was not included as part of the research programme. However during the course of the trials it was noted that the plants with mulch, produced a large number of fine surface roots both in the topsoil and also in the mulch. The probable reasons for the increased root activity were: higher soil moisture, more even soil temperature and a supply of nutrients from the mulch. These fine roots were produced by the plants to exploit the beneficial conditions provided by the mulch. During the period of drought far less surface roots were seen. These roots were definitely not part of the structural root system of the plant. The plants included in the trials were at least five years old prior to the application of mulch and were able to rely on their deeper roots for moisture and nutrients during the drought. If a grapevine is able to obtain moisture and nutrients from the top part of the soil profile it will do so, as it uses far less energy in the process. The development of surface roots by grapevines, as a result of the use of mulch, posed no problem in the research trials.

In the autumn of 2001, while the drought was in full force, it was noted that the plants with mulch retained their leaves for a longer period than those without mulch.

Date of budburst

The growth stage of the individual vines was assessed in early October 2001 in order to determine whether the presence of mulch was affecting the date of budburst. The perception was that if soil temperatures were cooler under mulch in the spring then bud burst would be delayed. The average daily soil temperature in September and early October under mulch was slightly cooler than in the bare soil. However the average temperature in the bare soil fluctuated markedly according to whether the day was cloudy or sunny. No differences in budburst between mulched and unmulched vines were observed.

THE USE OF MULCH BUFFERED SOIL TEMPERATURES. THE ROOTS OF THE GRAPEVINES UNDER MULCH ARE SUBJECT TO A MUCH MORE EVEN TEMPERATURE.

6

SOIL MICRO-ORGANISMS

General soil fungal, bacterial and yeast numbers were monitored as an indicator of changes in the soil microbial environment following the application of mulch. Soil samples were collected from the trial sites annually. Soil samples were washed, dilution plated and micro organisms counted after incubation.

The method used to count the soil micro organisms did not differentiate the species of fungi, bacteria and yeast present but provided an indication of the comparative numbers present in each of the samples.

One potential benefit of using mulch is an increase in soil fungal numbers. Soil fungi play an important role in improving soil structure through aggregate formation. In other cropping systems, mulch application increased microbial activity and biomass in soil (Manna et al. 2001) and reduced the severity of some above ground diseases of plants in crops such as tomatoes (Abbasi et al. 2002).

Soil fungi are important for the breakdown of complex organic plant residues as part of nutrient cycling. Many of the soils used for grape growing have low natural levels of fungi and increases in these microbes are desirable for the previously mentioned reasons.

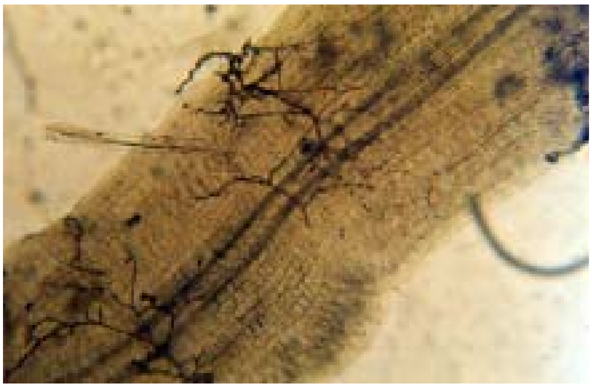
In all three seasons the number of fungi in the soil under the mulch was consistently higher than the unmulched control (Figure 5). Some seasonal variation occurred, due to different weather conditions experienced over the duration of the trials. Further investigation of fungal numbers in successive seasons would be required to see if the downward trend observed in the third season was due to seasonal variation or if the spike of microbial activity had peaked.

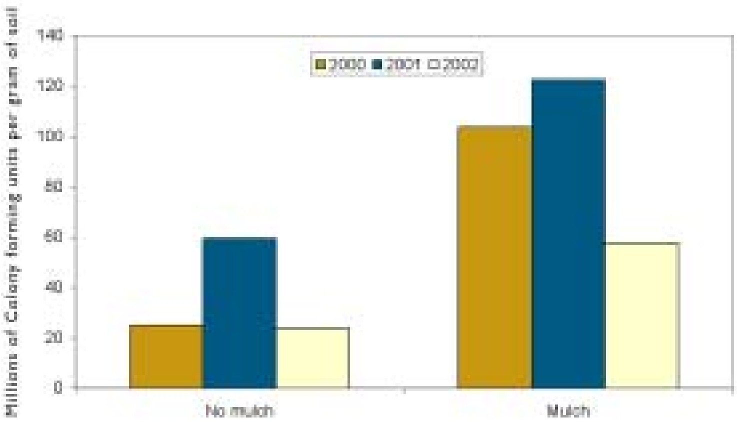
Mycorrhizal fungi

Following the successful detection of increases in total soil fungi, a more detailed investigation of the mycorrhizal fungi associated with plant roots was initiated in the third season. Samples of grape roots were stained and prepared on microscope slides so ten undamaged root tips could be observed for each sample. Each root tip was scored for the presence or absence of mycorrhizal fungi to give a percentage of root tips colonised per sample.

Mycorrhizal fungi increase the effective root surface area of plants growing in the soil. These specialised fungi have been reported to have many beneficial effects on a range of commercially grown crops.

All of the mulch treatments at the four sites had a significantly higher percentage (93.0%), of root tips colonised by mycorrhizal fungi compared to the no mulch control (59.3%).





SOIL FUNGAL NUMBERS INCREASED AS A RESULT OF USING MULCH.

Figure 5. Changes in soil fungal numbers at Site 3 over three seasons following a single application of mulch

7

GRAPE PRUNINGS IN MULCH AND POTENTIAL BOTRYTIS INOCULUM

During the mulch project samples of mulch were collected from the trial sites and incubated in the lab to determine if *Botrytis cinerea* was present. Of the 640 samples from the four trial sites only one sample had detectable levels of *B. cinerea* in the mulch, and on only one occasion.

Mulches containing grape prunings have been considered a source of inoculum for botrytis bunch rot. Bunch rot, caused by *Botrytis cinerea,* tends to be the most important disease problem that grape growers face during an average year.

Most vineyards today use a mulching mower to chop their prunings, leaving the chopped material in the inter-row. A significant amount of prunings remains unchopped under the vines. These large pieces of prunings provide an ideal substrate on which botrytis is able to germinate and sporulate, given warm moist weather. In a vineyard using undervine mulch, prunings are first removed to incorporate into a mulch mixture and then the mulch is applied to the area under the vine. There is thus far less raw pruning material, on which botrytis can grow, present in a mulched vineyard.

USING GRAPE PRUNINGS IN THE MULCH DID NOT RESULT IN INCREASED BOTRYTIS INOCULUM LEVELS.

8

WEED CONTROL

Weed numbers were assessed at all trial sites to determine the ability of a deep mulch to suppress weeds. Single weeds were counted regardless of the surface area of the plot that the weed was covering. This method gave an indication of the number of new weed seedlings present but did not indicate the area of the plot covered by weeds.

The results from assessments of weed numbers at one of the four sites are presented in Figure 6. Weed numbers on the non-mulched plots were considerably higher than on the mulched plots. A herbicide application was applied during January 2000 with noticeable effects on the number of weeds observed in March 2000. These results were collected during the 1999/2000 season at site 4 where a tall cover crop had been allowed to seed over the summer.

When the weed numbers were surveyed during April 2000 the mulch had decomposed to a point where a number of the components were no longer recognisable. At this stage the mulch provided an ideal seed bed for the germination of new weed seeds. The weeds observed growing on the mulched plots in April 2000 were growing in the mulch rather than growing up from below the mulch. The weeds were the result of the germination of seeds deposited in the mulch from the seeding cover crops in the inter row. At the other sites where the cover crops had not been allowed to seed the weed numbers were much lower.

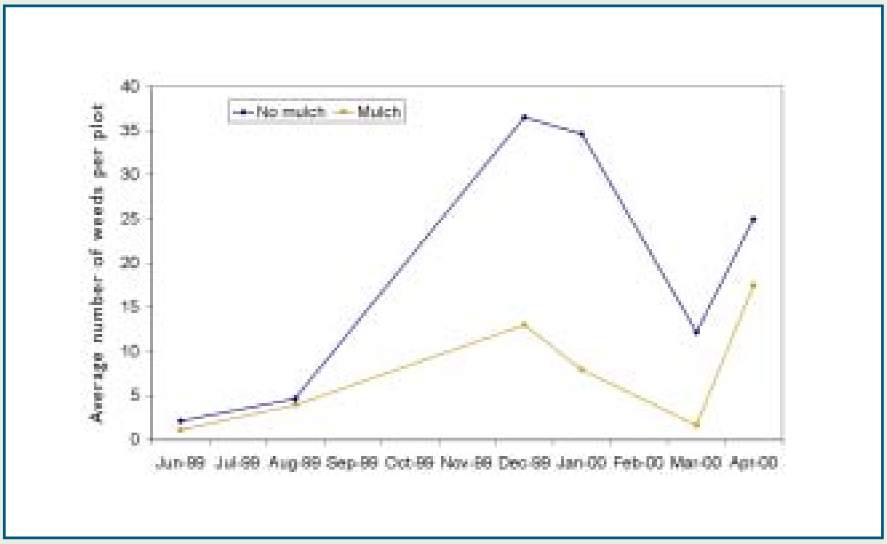


Figure 6. **Example of trend in weed numbers observed during 1999/2000 season at site 4**

8 CONT...

Suppression of weeds was observed at the four trial sites, but it is not possible to suggest how long this would continue as spot spraying of weeds was conducted at all sites as part of the normal vineyard practice. The level of weed suppression obtained from a mulch will depend on the thickness of mulch, how coarse the mulch is when applied and how cover crops and other potential sources of seeds are managed. Australian research (K. Webster pers. com) suggests that mulching should provide 12 to 18 months of weed suppression following application. The Australian researchers also recommend a 7.5 cm depth of composted mulch as a practical and economic rate of application (Buckerfield and Webster, 1998).

Mulching is just another tool that can be used as part of an integrated method of weed control. Weed suppression will be one of the first benefits observed, but probably also the shortest lived in most situations.

An indirect benefit of reducing herbicide applications is fewer tractor rounds spraying weeds, with savings of fuel, and reduced soil compaction in the wheel rows.

MULCH CAN BE USED TO SUPPRESS WEEDS AS PART OF A VINEYARD MANAGEMENT PROGRAMME

9

WORM POPULATIONS

Worm numbers were counted at all trial sites in August 1999 and again in December 2001. A hole was dug 25 cm by 25 cm to a depth of 25 cm and worms were counted cleaned and weighed.

Worm numbers at all of the vineyard sites in 1999 were low. Following the reports from Australian researchers (Buckerfield & Webster 1999, 2000, 2001) we expected to see increases in worm numbers at all of the sites following the application of mulch. Our counting of worm numbers in December 2001 again showed that worm numbers were low. This was the case in both the mulched and non-mulched control plots. December 2001 followed two months of very high rainfall when we expected worm numbers to have increased. We suspect that the extremely dry environmental conditions during much of the trial period suppressed worm numbers.

MULCHING DID NOT RESULT IN AN INCREASE IN EARTHWORM NUMBERS IN MARLBOROUGH UNDER THE DRY ENVIRONMENTAL CONDITIONS EXPERIENCED DURING THE TRIAL PERIOD.

10

MULCH LONGEVITY

Mulch depth was measured four times directly under the grapevines in the centre of the mulch pile in July 1999, May 2000, July 2001 and June 2002. Depth was measured using a marked depth stick.

As the mulch was freshly mixed prior to application there was a lot of bulk but very little weight. As the mulches that were applied were not composted and some of the components were bulky (greenwaste), a large proportion of the initial volume was actually air space. Initially, in the months after application, the mulch went through a settling down period during which time it compacted. Hence the depth of the mulch decreased rapidly over the first year (Figure 7).

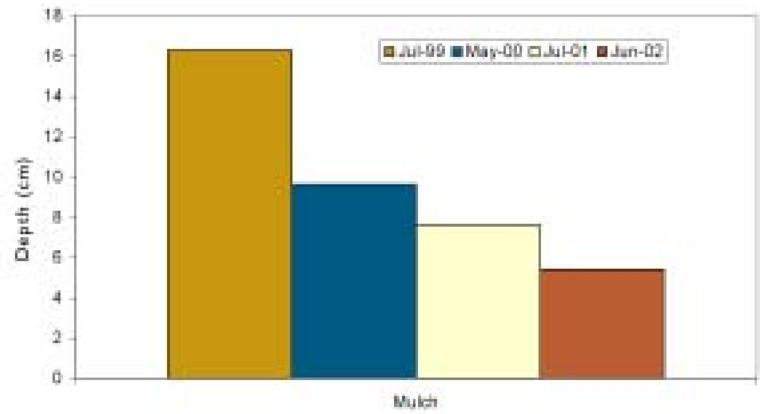


Figure 7. **Change in depth of mulch applied at site 1**

The average decrease in depth for the four treatments at site 1 over the first year was 6.6 cm, from an initial depth of 16.3 cm. This was a 40 percent loss of the original height. Three years after application the mulch was one third of its original height.

In a trial at Ruakura, near Hamilton, New Zealand, comparing a range of different mulches over two years, reductions of 45 to 82 percent of the initial depth of 100 mm were found.

It was noticed at site 2 that the mulch spread sideways a lot more than at the other three sites. Birds also appeared to spread the mulch around more at site 2. Surface rocks at two of the sites helped to keep the much in place.

INITIAL DECREASE IN MULCH DEPTH IS DUE TO COMPACTION, ESPECIALLY WITH BULKY UNCOMPOSTED MATERIALS. HOWEVER FURTHER REDUCTION OCCURS VIA DECOMPOSITION.

11

PLANT INDUCED RESISTANCE

Grape leaves were collected and frozen in liquid nitrogen in January and March 2000. At a later date these leaves were analysed for the enzyme peroxidase. Peroxidase activity in the leaves is thought to be an indication of induced resistance activity in the plants. The January and March analyses found an increase in peroxidase activity in some of the mulched treatments.

Once increased peroxidase enzyme levels were established, it was then necessary to demonstrate whether this resulted in lower disease levels on the plant. Had the plants become more resistant to disease? No consistent effect on foliar or bunch diseases was observed under Marlborough conditions, (as outlined in section 18). There was little Botrytis bunch rot disease pressure during the 1999/2000 season. It was not possible to demonstrate whether the plants had become more resistant to disease as a result of the use of mulch.

SOME INCREASE IN THE ACTIVITY OF INDUCED RESISTANCE ENZYMES WAS DETECTED IN GRAPE LEAVES. HOWEVER NO DIFFERENCE IN ACTUAL DISEASE LEVELS WAS OBSERVED UNDER MARLBOROUGH'S LOW DISEASE PRESSURE CONDITIONS.

12

PETIOLE ANALYSES

Grape petioles were collected at 80% flowering in December 1999, 2000 and 2001. 80 petiole samples were analysed each year. (Ten petioles per replicate plot were bulked together. Five mulch treatments x four replicates x four properties). Petiole analysis was conducted by Hill Laboratories Ltd.

The individual analysis results for the four mulch treatments did not vary greatly. For this reason the results have been averaged and are compared with the unmulched treatment (Table 7). The normal range of nutrients as recommended by Hill Laboratories Ltd is presented at the bottom of table 7.

Table 7. Petiole nutrient status of grapevines from 1999 to 2001 due to the addition of mulch

Site	Treatment	Year	NO_3-N (ug/g)	N (%)	P (%)	K (%)
Site 1	No mulch	1999	500		0.30	1.95
Site 1	Mulch mean	1999	1617		0.28	2.98
Site 1	No mulch	2000	250	0.78	0.65	2.35
Site 1	Mulch mean	2000	264	0.78	0.66	3.16
Site 1	No mulch	2001	2346	1.50	0.27	1.55
Site 1	Mulch mean	2001	2560	1.54	0.35	2.68
Site 2	No mulch	1999	1131		0.41	2.48
Site 2	Mulch mean	1999	2656		0.61	3.20
Site 2	No mulch	2000	275	0.78	0.34	2.13
Site 2	Mulch mean	2000	505	0.89	0.40	2.47
Site 2	No mulch	2001	809	1.08	0.62	2.40
Site 2	Mulch mean	2001	2530	1.39	0.55	2.83
Site 3	No mulch	1999	200		0.50	2.38
Site 3	Mulch mean	1999	619		0.69	3.98
Site 3	No mulch	2000	263	0.78	0.61	2.58
Site 3	Mulch mean	2000	275	0.74	0.65	3.68
Site 3	No mulch	2001	186	0.90	0.88	2.93
Site 3	Mulch mean	2001	361	0.98	0.95	3.32
Site 4	No mulch	1999	1963		0.17	3.65
Site 4	Mulch mean	1999	3169		0.26	4.54
Site 4	No mulch	2000	250	0.68	0.37	3.40
Site 4	Mulch mean	2000	250	0.83	0.34	3.63
Site 4	No mulch	2001	3562	2.00	0.26	3.93
Site 4	Mulch mean	2001	3147	1.76	0.40	5.18
	Normal range		570-1750	0.8-1.0	0.21-0.50	1.5-2.5

Nitrate nitrogen (NO_3)

Nitrate levels increased dramatically at all sites in 1999 after the application of mulch (Figure 8). There was no difference in nitrate nitrogen between mulch treatments and the unmulched control in 2000.

In 2001 the petiole nitrate levels were again high. At two properties (Site 1 and Site 4) the petiole nitrate levels were also very high in the unmulched control plots. A possible explanation could be that there had been sideways movement of nitrate between adjoining plots.

The nitrate results over the three years suggested that the marked differences in petiole nitrate between years was largely attributable to climatic differences among the three seasons. 1999 and 2001 were wet prior to the petiole samples being taken and 2000 was dry.

At three of the sites (Site 1, Site 2 and Site 4) in 2001, the petiole nitrate levels were well above those recommended by Hill Laboratories Ltd (570 to 1750 ug/g).

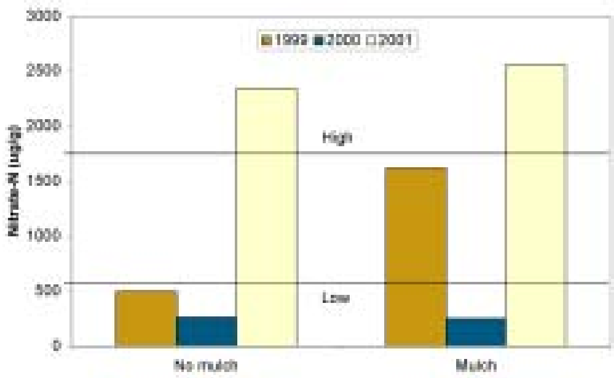


Figure 8

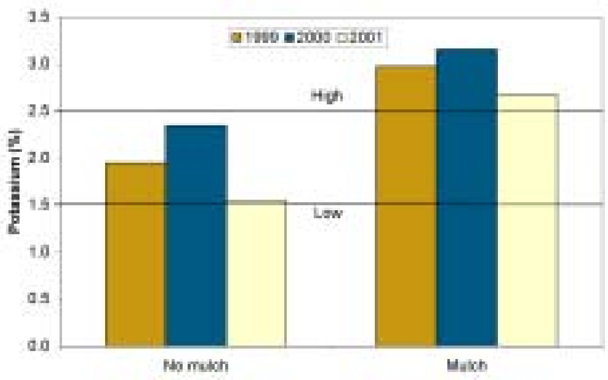


Figure 9

Figures 8 and 9. Changes in petiole nitrate and potassium at site 1 from 1999 to 2001. Changes at site 1 are indicative of the changes at all sites.

The area on the graphs between the low and high lines indicates the normal range of nutrients, as recommended by Hill Laboratories Ltd.

Total N

Total nitrogen levels were measured in 2000 and 2001. Recommended levels are 0.8-1 percent. Total nitrogen in the petioles appeared to be less affected by soil moisture prior to sampling than nitrate nitrogen. All properties showed raised total nitrogen in 2001 compared to 2000.

Phosphorus

Petiole phosphorus levels varied markedly between the three years and also between sites as shown in table 7.

Potassium

The use of mulch increased the petiole potassium levels in all three years at all four sites (Figure 9). However, the increase in petiole potassium was nowhere near as large as the increase in soil potassium.

MULCH DID HAVE AN EFFECT ON RAISING PETIOLE NUTRIENT LEVELS, ESPECIALLY NITRATE, BUT THE RESPONSE WAS DEPENDENT ON SITE AND SPRING RAINFALL.

13

LEAF ANALYSES

Grape leaves were collected in February 1999, 2000, 2001 and 2002. 20 leaf samples were analysed each year. (Ten leaves per replicate plot were bulked together. Five mulch treatments x four properties). The replicates were bulked together to reduce the cost of analysis. Leaf analysis was conducted by Hill Laboratories Ltd.

The spring of 1999 was very wet encouraging a large release of nutrients. Hence in 2000, a general increase in nitrogen, phosphorus and potassium was noted at all the four sites. In February 2001, two years after the mulch was applied, the major nutrients, nitrogen and phosphorus, were lower at all four sites compared to 2000. In some cases, the levels were lower than they were initially without mulch. A major influence during the 2000/2001 season was a very long dry spell, which limited plant nutrient uptake due to much lower soil moisture levels.

Figure 10 illustrates the increased leaf nitrogen levels due to the application of mulch. The leaf nutrient levels in the unmulched vines increased considerably in 2002 at all sites. This may have been due to sideways leaching from adjacent plots. Leaf nitrogen levels were higher at sites 2, 3 and 4 after three years than they were prior to the addition of mulch.

Leaf phosphorus levels after three years were basically the same as they were prior to the addition of mulch.

Leaf potassium levels (Figure 11) in 2002 were higher than they were before mulch was applied, although they were declining from the initial increase at three of the sites.

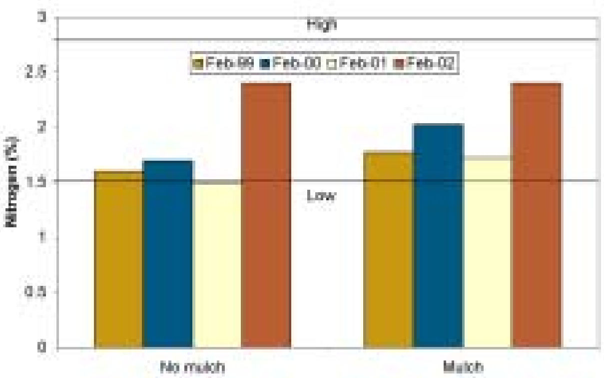


Figure 10

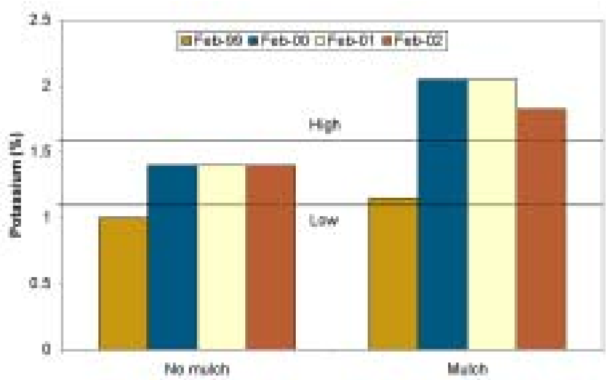


Figure 11

Figures 10 and 11. Changes in leaf nitrogen and potassium at site 1 from 1999 to 2002. Changes at site 1 are indicative of the changes at all sites.

Table 8. Overall change in leaf nutrient status from 1999 to 2002 due to the addition of mulch

Site		Site 1	Site 2	Site 3	Site 4
N	%	-0.18	+0.18	+0.20	+0.55
P	%	+0.02	-0.03	-0.03	+0.02
K	%	+0.28	+0.05	+0.30	+0.13

THE USE OF MULCH INCREASED LEAF NITROGEN AND POTASSIUM LEVELS BUT NOT PHOSPHORUS LEVELS.

14

YIELD

All trial plots were harvested by hand in 2000, 2001 and 2002. Total fruit weight, total number of bunches and 100 berry weight were recorded for each plot.

There were some slight effects of mulch on yield over the three years. However these effects were not consistent among treatments and the four sites. Some trends with increased total fruit weight in the mulches containing animal manure were observed. There were large variations in yield among the four sites, however this was largely due to management practices rather than the effects of mulch.

There was also a large variation in yield within each site for the three years. Yield was lowest in 2000 and highest in 2002. This was almost entirely due to the temperature influence during bud initiation and flowering. December 2000 recorded above average temperatures during bud initiation as did December 2001 during flowering, therefore the yield in 2002 was well above average.

It should be noted that the mulch had no negative effect on yield.

In Australia increases in yield following the use of mulch were generally found to be the result of increased survival of bunches post flowering (K. Webster. pers com). In New Zealand, high temperatures during flowering that can cause flower abortion do not occur. The unmulched control plots did not lose yield due to extreme plant stress, as they do in Australia, therefore the use of mulch had no beneficial effect on yield, due to increased fruit retention.

UNDER MARLBOROUGH CONDITIONS THE USE OF MULCH DID NOT SIGNIFICANTLY AFFECT YIELD.

15

JUICE BRIX, TITRATABLE ACIDITY AND pH

At harvest 100 berry samples were collected from each of the trial plots. These samples were frozen for juice analysis at a later date. Juice analysis was conducted by Montana Wines Marlborough laboratory. Each juice sample was tested for Brix, titratable acidity and pH and the results were compared to see if the use of mulch had any effect on juice quality as defined by these parameters.

Juice samples from replicates of the same mulch treatment were combined and tested for the following cations: ammonium, potassium, calcium, magnesium and manganese.

A major concern of grape growers and winemakers was the effects that the use of mulch may have on juice quality. In the three seasons following mulch application no significant differences in Brix and titratable acidity were detected between grapes from plants with or without mulch.

The changes in pH of juice are summarised in Table 9. They were not consistent among sites and years. However it is likely that the increases in pH were linked to the increases in juice potassium as outlined in Table 10.

15 CONT…

Table 9. Overall change in juice pH from 2000 to 2002 due to the addition of mulch

Site	Year	Treatment Mulch 1	Mulch 2	Mulch 3	Mulch 4
Site 1	2000	+0.02	-0.03	+0.08*	+0.10*
	2001	+0.13*	+0.10	+0.07	+0.11*
	2002	+0.09*	+0.02	+0.04	+0.10*
Site 2	2000	-0.02	-0.06	-0.02	-0.03
	2001	+0.12*	+0.07	+0.07	+0.06
	2002	-0.02	-0.04	-0.03	+0.02
Site 3	2000	+0.06*	+0.11*	+0.06*	+0.11*
	2001	+0.07*	+0.06*	+0.07*	+0.12*
	2002	+0.05	+0.05	+0.07*	+0.08*
Site 4	2000	+0.05	+0.04	+0.18*	+0.06
	2001	+0.12*	+0.10*	+0.17*	+0.09
	2002	+0.08*	+0.07*	+0.12*	+0.06*

* indicates means that are significantly different (P<0.05) to the no mulch treatment.

JUICE BRIX AND TITRATABLE ACIDITY WERE NOT AFFECTED BY THE USE OF MULCH. SOME SMALL INCREASES IN JUICE pH WERE OBSERVED.

16

YEAST AVAILABLE NITROGEN [YAN]

Yeast available nitrogen (YAN) is a fruit quality parameter that can affect wine fermentation. Samples of the juice were analysed by Nobilo's Marlborough Winery for yeast available nitrogen. Due to the cost of testing only juice from sites 2 and 3 was analysed for YAN.

There was a significant increase in YAN of juice from site 3 at harvest 2000, in response to mulching. At site 2 no significant difference in YAN of juice in response to mulching was observed (Figure 12).

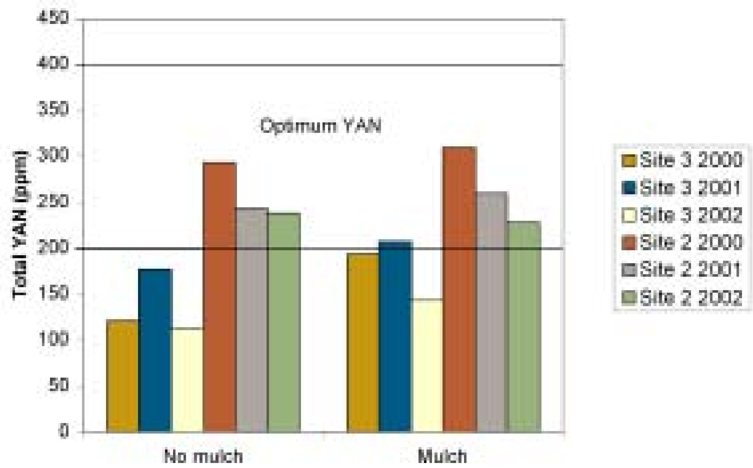


Figure 12. Yeast Available Nitrogen (YAN) for two vineyard trial sites during the 2000, 2001 and 2002 vintages.

At site 3 during the 2000 harvest, YAN of grape juice produced in the non-mulched plots was 120.2 mg N/L, which was lower than the optimum of 200 to 400 mg N/L. In plots that had received mulch, YAN was significantly higher (193.5 mg N/L). At site 2, YAN levels in juice were higher than those at site 3 irrespective of treatment, with similar levels of YAN in non-mulched plots (293.3 mg N/L) compared to mulched plots (309.8 mg N/L).

Similar results were obtained in the second and third seasons (2001 and 2002). Where YAN in juice was lower than optimum at site 3, mulching provided an increase in juice YAN. At site 2, where YAN was already at the required level, mulching provided no significant added benefit in this respect.

Our research suggests that using under-vine mulches has beneficial effects on juice nitrogen and hence wine quality at some vineyard sites. This is particularly the case where YAN in juice is at lower than optimum levels.

THE APPLICATION OF UNDERVINE MULCH CONTAINING SIGNIFICANT AMOUNTS OF NITROGEN INCREASED YEAST AVAILABLE NITROGEN IN GRAPE JUICE WHERE YAN WOULD OTHERWISE HAVE BEEN LOW.

17

JUICE POTASSIUM

Grape skins and some of the other waste streams used in this project are known to have high levels of potassium. At the start of the project some winemakers and growers were concerned about the effect on wine potassium levels and hence pH from the use of mulch containing grape marc.

High juice potassium content can be a problem in winemaking. Potassium excess neutralises (tartaric) acids producing a high pH wine. Potassium at low levels may result in excessive acidity. The general guidelines for good quality fruit under New Zealand conditions suggest that a juice potassium value of 900 - 1300 ppm is desirable (Turner J, Hill Laboratories Ltd.).

During the three years of the trial, vines with mulch had a higher juice potassium content than those without mulch, for individual trial sites (Table 10). However, there was considerable site and seasonal variation. The variation in juice potassium levels among the seasons and sites was greater than the variation due to mulch. At site 1, for the no mulch and average mulch, a 36% and 42% reduction respectively was found in the juice potassium level, between the 2000 and 2001 seasons.

The increase in juice potassium within a season due to mulch was much less than the between season variation due to other factors such as climate and crop load. At Site 1 during 2000 the mulch juice averaged 2085 ppm potassium and the no mulch juice 1768ppm. The increase in potassium on the mulched plots was 17.9 percent.

Table 10. Juice potassium levels (ppm) for grapes from mulched and unmulched plants

Site	Year	No Mulch	Mulch Mean	% increse due to mulch
Site 1	2000	1768	2085	17.9
	2001	1121	1205	7.5
	2002	1200	1415	17.9
Site 2	2000	1346	1515	12.6
	2001	1047	1192	13.8
	2002	1702	1822	7.1
Site 3	2000	1293	1399	8.2
	2001	1482	1677	13.2
	2002	1546	1693	9.5
Site 4	2000	1731	2047	18.3
	2001	1080	1185	9.7
	2002	1313	1531	16.6

It is likely that the increases in juice pH outlined in Table 9 are linked to the increases in juice potassium.

Soil test results (Figure 3), showed that the use of mulch as produced for these experiments, increased the amount of potassium present in the soil by 400 percent. Juice potassium increased slightly, however the increase was very small compared to the increase in soil potassium. A possible explanation is that the vines may be able to regulate the rate of potassium uptake.

THE USE OF MULCH DID INCREASE JUICE POTASSIUM. HOWEVER THERE WAS GREATER SEASONAL AND SITE VARIATION THAN VARIATION DUE TO THE EFFECT OF MULCH.

BOTRYTIS BUNCH ROT

Botrytis bunch rot is the major disease in winegrape production in New Zealand. Botrytis bunch rot incidence was assessed in the field fortnightly from January until harvest at all trial sites over three years. Botrytis severity was also assessed immediately prior to harvest in each of the three years. There were no instances where the presence of mulch significantly increased the level of Botrytis bunch rot. However, there were some instances where the presence of mulch reduced the incidence of the disease (Table 11). Generally, where disease incidence was reduced by the mulch treatments, bunch rot severity was also found to be reduced.

Mulch containing grape prunings did not increase the severity of Botrytis bunch rot on grapevines compared to the unmulched grape vines. This result is consistent with previous investigations demonstrating that almost all mulch samples were free of *B. cinerea* (Mundy & Agnew 2001).

Table 11. Effect of mulch on percentage incidence of Botrytis bunch rot on grape bunches

		Treatment				
Site	Year	Mulch 1	Mulch 2	Mulch 3	Mulch 4	No mulch
Site 1	2000	1	0*	1	0*	1
	2001	0*	0*	2	1	2
	2002	25	12*	11*	30	28
Site 2	2000	47	48	58	34	40
	2001	1	5	8	5	3
	2002	29	18*	25	25	28
Site 3	2000	2	0	3	1	1
	2001	1	2	2	3	2
	2002	14	11	13	22	13
Site 4	2000	23	19*	22	24	25
	2001	10*	15	13	12	13
	2002	3	8	8	8	4

* indicates means that are significantly different ($P<0.05$) to the no mulch treatment. (Each individual mulch treatment was only compared with the no-mulch treatment, not with the other mulch treatments).

Seasonal differences and site management had a greater effect on disease levels in the vineyards than the mulch treatments. The 2000/2001 season in Marlborough was extremely dry and botrytis levels were very low. Although the 2001/2002 season experienced a wet spring and summer the severity of Botrytis bunch rot was also low. The relatively low disease levels in 2001/2002 were because *B. cinerea* inoculum was low as a result of the previous dry season.

FOLLOWING THREE YEARS OF INVESTIGATION AT FOUR SITES WE CONCLUDE THAT UNDER THE CONDITIONS INVESTIGATED, THE MULCHES HAD ONLY MINOR EFFECTS ON INCIDENCE AND SEVERITY OF BOTRYTIS BUNCH ROTS ON GRAPEVINES.

19

VEGETATIVE GROWTH

Shoot length measurements were conducted three or four times during November/December 1999, 2000 and 2001, prior to shoot trimming, to determine whether mulch was influencing vegetative growth. Ten shoots were chosen at random within each plot and their total length was measured.

The vegetative growth for the three years varied considerably due to large climatic differences in the growing seasons. The trend at all sites was for the mulched treatments to have slightly longer shoots than the unmulched treatments. However these differences were not statistically significant and the differences were not noticeable enough to be apparent to the naked eye in the vineyard.

20

PRUNING WEIGHTS

Pruning weights give an indication of the vegetative growth of vines over the season and the carbohydrate reserves laid down for the next season. Pruning weight measurements were conducted in 2000, 2001 and 2002. No clear and consistent pattern of mulch on the pruning weights was observed over the four sites. There were large variations in prunings weights among plots of the same mulch treatment at each site. This is probably a reflection of variation within the vineyard.

The only conclusive pattern to emerge from the pruning weight data was a marked difference between individual bays within a vineyard and also between vineyards. Differences between vineyards were to be expected due to differences in soil type, rootstock, clone, number of buds laid down etc.

MANAGEMENT PRACTICE HAD A GREATER EFFECT ON PRUNING WEIGHTS THAN MULCH TREATMENT DID.

EFFECT OF MULCH ON CANOPY FROST RISK

Concerns were raised that applying a thick layer of mulch under vines would increase the risk of frost damage on the vines. This follows the line of thought that to lessen frost risk you cultivate between rows and eliminate vegetation under the vines with the use of herbicides. Bare soils are able to absorb more heat from the sun during the day and this heat is then released during the night helping to keep the air temperature slightly warmer than would be the case in the air above soil covered in vegetation.

Air temperatures were measured in the grape canopy above bare soil and above mulched soil. The inter-row comprised a short cover crop. Figure 13 displays the temperatures over the spring, when frost risk to vines is greatest. Four lines are displayed on the graph, although it appears as if there are only two. There was no apparent depression in the air temperature above the mulched plots. This was the case throughout the year.

The likely reason for no depression in air temperature above the mulch was that the mulch was only applied under the vines and not in the inter-row. The mulch strips only occupied approximately 25 percent of the vineyard floor area. The other 75 percent of the vineyard not covered in mulch was presumably radiating heat at night.

If a grower were considering applying mulch to the whole vineyard floor area, caution would be advised, as the frost risk would be likely to increase.

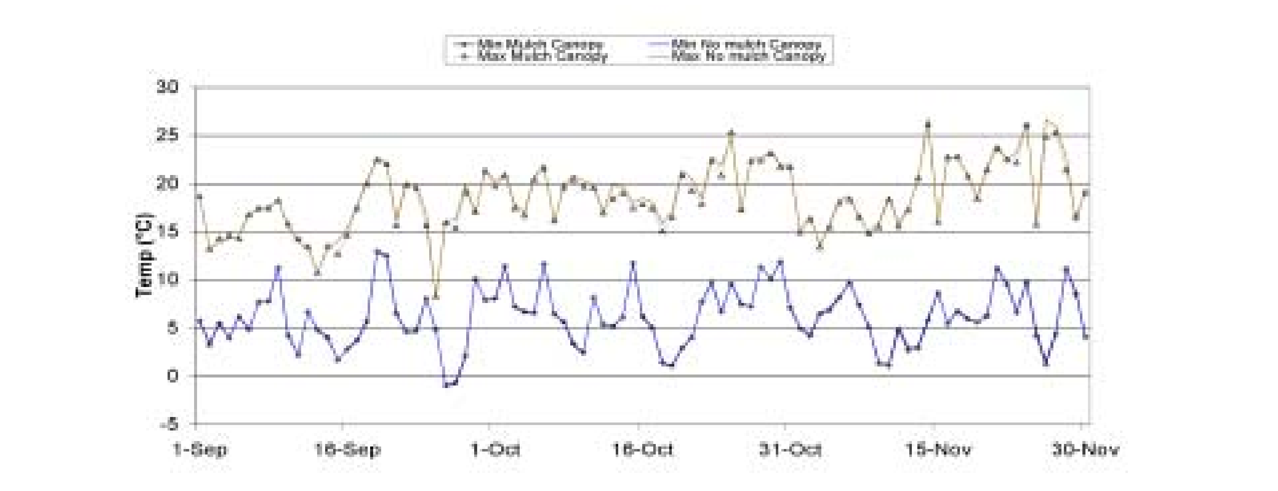


Figure 13. Air temperatures at the level of the fruiting wire - Site 2, 2000

THE USE OF UNDERVINE MULCH DID NOT INCREASE THE FROST RISK TO THE VINES.

PRACTICAL CONSIDERATIONS FOR THE USE OF MULCH

1

DESIRABLE PROPERTIES OF MULCH

Many organic materials can be used as mulch, but not all are suitable. Desirable properties for mulch are: (Sections 23-26 from Spiers, Fietje and Agnew 2002).

- Weed free
- Pathogen free
- Biologically stable
- Coarse particle size
- Non-toxic to the environment
- Reasonable density
- Good longevity
- Good wettability
- Easy to apply
- Able to support beneficial organisms
- Attractive visually and free of unpleasant odour
- Reasonable cost
- Available in the required quantities

A material that satisfied all these criteria would be ideal. In reality, a compromise must be reached and materials chosen that meet as many of the criteria as possible.

2

COMPOSTING

The process of composting has been defined as a way of managing solid waste where the organic component is biologically decomposed under controlled conditions to a state in which it can be handled, stored and applied to land without adversely affecting the environment. The biological process generates heat and requires air.

Compost and mulch differ. Mulch can be anything to cover the soil while compost is organic material that has undergone a composting process. Compost can be used as a mulch, but a mulch may not be a good compost. Mulch is placed on the soil surface without mixing into the soil, whereas compost is generally mixed in and will be in close contact with plant roots. For this reason the quality of compost is more critical than for mulch.

In general, mulches used in vineyards should be composted, although the degree of composting depends on the type of materials used. Composting is often necessary so that the mulch has more of the desirable properties outlined earlier. For example, weed seeds and pathogens are likely to be killed by the heating cycle during composting, provided all materials are subject to temperatures of at least 55°C for three days or longer.

Wastes with the potential to become putrid, such as animal manure or food processing waste, require composting to stabilise them and reduce the potential for offensive odours and attractiveness to pests such as flies and rodents. Composting also reduces the levels of compounds in the waste that may damage plant roots. In addition, a certain level of decomposition is necessary to produce a substrate suitable for colonisation by beneficial micro-organisms. Composting and stabilisation will continue after the mulch is spread, albeit at a slower rate.

3

METHODS OF COMPOSTING

Small scale, on-farm methods include the windrow method and the aerated static pile method. The windrow method is the simplest; where materials are mixed and formed into an elongated pile. The pile is turned periodically to mix the ingredients and allow air to infiltrate. The aerated static pile method uses a blower and perforated pipes to force air through the pile. A layer of mature compost may be used to insulate the pile so that turning is unnecessary and to act as a biofilter to treat any odours generated from the pile.

Large scale, commercial composting includes both the windrow and the aerated static pile method, along with in-vessel systems. In-vessel systems enclose the composting process in order to control temperature, moisture content and odour release. This way very efficient composting of putrescible wastes such as sewage sludge can be achieved, but at relatively high cost.

Costs for on-farm composting methods range from $10 to $30 per tonne. Commercial compost generally costs from $40 to $60 per tonne, but mulch can be less expensive since mulch is often a by-product from the composting process.

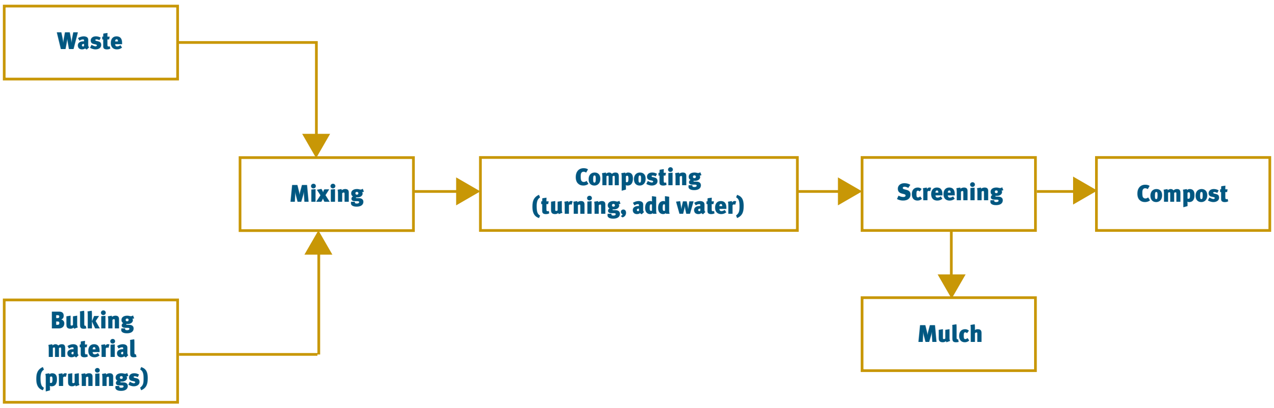


Figure 14. Typical process schematic for large scale composting

Current vineyard composting practice

Composting on Marlborough vineyards currently uses the windrow method. Typically the ingredients are mixed together in April as the grape marc becomes available from the winery. The windrow requires turning approximately fortnightly during May, June, July and possibly August. It is essential that turning is thorough. The amount of rainfall that has fallen on the windrow during the composting process will determine whether water needs to be added. Recycling of any leachate collected back onto the pile, is the easiest method to dispose of it. This avoids having to dispose of it onto the vineyard in a manner that is permitted and does not exceed the recommended levels as outlined in section 6.

The compost would be ready to apply to the vineyard by September. Spring is recommended as the best time for application of compost to the vineyard as the grapes are best able to make use of any nutrients that may be released after the first rainfall.

4

MULCH BLEND

Mulch can consist of a single ingredient, but more often a blend is used, for example vineyard prunings, grape marc, greenwaste and bark. Once the properties of each ingredient are known, the ideal blend can be calculated. The method used is beyond the scope of this booklet, but requires knowledge of nutrient content, moisture content and organic matter (or more usefully, the readily degradable organic matter) content. The ideal blend will compost efficiently and will not cause problems such as nitrogen fixation when applied.

5

FACTORS TO CONSIDER WHEN DECIDING TO APPLY MULCH

The costs associated with putting a mulch under grapevines will vary considerably depending on a number of factors. Some of these factors are:

- The statutory requirements that you have to fulfil in order to make and store the mulch, e.g. construction of a pad on which to make the compost.
- If making your own mulch, costs associated with collection of the ingredients and transportation to a site where the mulch is made and then transporting the mixed mulch back to your vineyard.
- The ingredients that are to be incorporated in the mulch and the volumes that are potentially available.
- The cost of making your own composted mulch in comparison to buying ready-made composted mulch.
- Nutrient composition of the mulch.

As previously discussed, benefits that may be gained from the use of mulch include possible reductions in: irrigation, herbicide applications, artificial fertiliser applications and diammonium phosphate additions to ferments in the winery. Long term improvements in soil and plant health should also be gained.

The costs associated with the application of a mulch need to be weighed up against the benefits that are likely to be derived from the use of mulch. It is possible to put a dollar value on some of the benefits that are likely to be derived from using mulch, however some of the benefits cannot be measured in dollar terms.

6

REGULATORY REQUIREMENTS FOR MAKING, STORING AND APPLICATION OF COMPOSTED MULCH

The Winegrowers Code of Practice recommends the following:
"Bund and seal the base of stockpile area with clay, but preferably concrete. The base should be sloped and a leachate collection system installed. Collected leachate could be pumped into the winery wastewater system or irrigated onto land. Locate stockpile clear of neighbours and public areas to reduce effects of odour."

Marlborough District Council regulatory requirements
The following information has been supplied by the Marlborough District Council. For readers in areas of New Zealand other than Marlborough you would be well advised to check out the regulations applying in your area. For full information and details of information referred to as Appendix P or J please contact the Marlborough District Council.

"It is likely that the discharge of leachate from composting systems would require a resource consent. Depending on the construction of the composting pad, it may also require a resource consent or building consent. Before installing a composting system you should provide Council with a plan of the system so that they can confirm whether or not a resource consent is required. If a resource consent is not required, Council can issue a certificate of compliance, which confirms the legality of the system"

Rule 1.8.9 from the Rural Zone of the Proposed Wairau Awatere Resource Management Plan, which is relevant to the discharge of wastewater/leachate, states:

Liquid Wastes
The discharge of liquid waste from the processing of fruit, vegetable, shellfish, fish or animal products onto or into land is a permitted activity subject to the following conditions:

1.8.9.1 The characteristics of the waste shall be such that the following levels are not exceeded:

Biological Oxygen Demand (BOD5)	5,000g/m^3,
Faecal coliforms	100/100 mL,
Free available chlorine	< 1 g/m^3

Other contaminants shall not exceed the toxicant limits for irrigation water quality which are set out in Appendix P. These limits are derived from the Australian Guidelines for Fresh and Marine Waters (Australian and New Zealand Environment and Conservation Council [ANZECC] 1992).
No objectionable odours can be detected at or beyond the legal boundary of the area on which the liquid waste is discharged.

1.8.9.2 The total nitrogen loading on the land to be used for the discharge shall not exceed 200 kg N/ha/yr.
1.8.9.3 The discharges shall be applied evenly over the disposal area at a rate not exceeding 10 mm/day.
1.8.9.4 The discharge shall not be within 20 metres of any surface water body.
1.8.9.5 There shall be no run-off of the waste into any surface water body.
1.8.9.6 A buffer zone of a minimum of 10 metres width shall be maintained between the area of discharge and the legal boundary of the land on which the liquid waste is discharged.
1.8.9.7 The discharge shall not be within any class NS catchment defined in Appendix J.

Rule 1.8.10, which is relevant to spreading compost or marc on land, states the following:

Solid Waste
The discharge of solid waste from the processing of untreated timber, fruit, vegetable, and shellfish products onto or into land is a permitted activity subject to the following conditions:

1.8.10.1 The waste shall not contain any substances classified as eco-toxic under the Hazardous Substances and New Organisms Regulations.
1.8.10.2 The discharge shall not be within any class NS catchment defined in Appendix J.
1.8.10.3 The characteristics of the waste shall be such that no shellfish flesh is included.

1.8.10.4 No objectionable odours can be detected at or beyond the legal boundary of the area of land on which the waste is discharged.
1.8.10.5 The total nitrogen loading on the land shall not exceed 100 kg N/ha/yr.
1.8.10.6 The amount of solids applied shall not exceed a depth of 50 mm per year, measured when applied.
1.8.10.7 The discharge shall not be within 20 metres of any surface water body.
1.8.10.8 There shall be no run-off of contaminants from the waste into any surface water body.
1.8.10.9 A buffer zone of a minimum of 5 metres width shall be maintained between the area of discharge and the legal boundary of the area of land on which the waste is discharged.

Comments
The requirement of rule 1.8.10.6, that the solid applied should not exceed 50 mm depth per year, needs to be examined to see if there is a logical reason why this depth should be used. In the case of vineyard mulch it is unlikely that it would be reapplied to the same area more than once every five years.

The requirement of rule 1.8.10.5, that the total nitrogen loading on the land shall not exceed 100 kg N/ha/year, needs to be given careful consideration prior to application of a mulch.

7

CONSTRUCTION OF A BUNDED PAD ON WHICH TO MAKE AND STORE COMPOSTED MULCH

The Marlborough District Council does not specify the design of the composting pad. It is up to the vineyard or winery to come up with a design and convince Council it will be suitable. Currently pads being built are either concrete or clay. One problem with concrete pads is that the acid from the grape marc eats into the concrete. For a clay pad to be impermeable it needs to be very thick (at least 200 - 250mm), regularly maintained and recompacted. Another option would be to install a synthetic liner in the clay. The pad should be designed so that leachate does not run off the pad, hence bunding is advisable.

An estimate was obtained from a roading contractor for the cost of constructing a clay pad on which to mix and store mulch. To construct a pad with clay base 80 m long by 10 m wide, would cost from $10,000 to $15,000. Where the pad includes a bund around the outside to retain leachate, the cost will be higher. If the pad is to be bunded, thought needs to be given as to how a front-end loader can easily work around the mulch pile in order to turn it.

The cost includes excavation of soil and assumes that the soil will be disposed of on site. The clay pad would be 200 mm deep and would likely be a mixture of compacted clay and fine quarry rock. The pad would slope to one point to a drainage sump and grate. This would drain to a leachate holding tank. The price of a holding tank is not included. The size of the holding tank would obviously depend on the size of the pad. For instance an 800 m^2 pad has the potential to collect 800 litres of water for every 1 mm of rain.

In most cases, in Marlborough's relatively dry climate you would expect little leachate, especially in a mulch mix containing absorbent material such as finely chopped grape prunings. However, given a large volume of rain, there is the potential for a lot of leachate to be collected, especially if the mulch is already fairly moist.

8

COST OF MACHINERY ASSOCIATED WITH MAKING AND APPLYING COMPOSTED MULCH

Approximate rates for the machinery are:

Prunings chopper / collector	$330/hour contract rate
Loader for mixing mulch	$ 85/hour contract rate
Truck for carting mulch	$ 65/hour contract rate
Mulch spreader wagon	$300/day hireage cost.

Currently in Marlborough, the machine that picks up and chops the prunings is a Kimco Chopper, operated by Rose Agricultural Ltd., under contract to Matador Estate. The chopper is able to cover an average of 3.25 ha per hour, when prunings are placed in every second row. This equates to a cost of $101.54 per ha to pick up and chop the prunings. In some cases in Marlborough, grape gondolas are used to collect and cart the prunings. Cartage to the storage site may be an additional cost.

Most of the vineyards that are making compost are currently mixing it with a front-end loader or with a digger that is able to sit on top of the pile.

A Blenheim company, Hortro Spread, has a specifically built wagon for spreading mulch. This wagon is available for hire at $300 per day, with the vineyard using its own tractor and loader. Alternatively, the whole spreading operation could be done under contract.

9

REQUIRED QUANTITIES AND POTENTAL MULCH MATERIALS

A rough calculation can be done to estimate the amount of mulch needed (Spiers, Fietje and Agnew 2002). The volume of mulch required, assuming a strip 0.5 m wide and an average of 5 cm deep is laid down each row, is about 85 m^3 per ha at a plant spacing of 3m x 1.8m. In Marlborough, application rates of composted mulch vary from about 55 m^3 to 100 m^3 per hectare.

From calculations of vineyard and winery waste generated (next section) it is estimated that the amount of compost produced will only allow mulch to be applied to a maximum of about one fifth of the vineyard area each year at an application rate of 55 m^3 per ha, or one eighth of the vineyard area each year if applied at 85 m^3 per ha.

To be more effective, a programme in which mulch was applied to one third of the vineyard each year would be needed. Table 12 sets out the amounts of mulch required if every vineyard in New Zealand were to be treated at 85 m^3 per ha every three years. In order to achieve this application rate more than half of the volume would need to be brought in from outside the vineyard.

Table 12. Volume of mulch required in different regions to treat the vineyard area at 85 m^3 per ha on a three-year reapplication interval

Region	Area of vines*	Volume of mulch
	Ha	m^3 per year
Marlborough	5,228	148,130
Hawkes Bay	3,072	87,040
Gisborne	1,963	55,620
Others	2,559	72,500
New plantings**	4,100	116,170
Total	16,922	479,460

* Source: www.nzwine.com
** Source: New Zealand Horticulture Facts & Figures 2001, HortResearch

The amount seems large, although it has to be compared to the size of the potential source of mulch ingredients. For example, the amount of bark generated by the forestry industry each year is over 1,300,000 m^3 annually. Other forestry industry wastes like sawdust and wood shavings are more widely available than bark. Suitable materials for mulch also include urban organic waste, animal manure and crop residues. Urban organic waste includes garden, or green waste, kitchen waste and biosolids. Biosolids, or sewage sludge, is gradually becoming more widely accepted, as modern composting techniques are used to produce a safe material.

The beneficial effect of soil amendment by biosolids is apparent in field trials. Animal manure can be most readily sourced from chicken and pig operations, as well as waste streams from meat and fish processing. Crop residues include fruit and vegetable wastes from fresh and processed crops. These crops are grown in the same districts as grapes in many cases. The diversion of these organic wastes from landfills into beneficial uses such as composting and mulching is strongly encouraged by local authorities.

Transport cost is a major factor influencing choice of ingredients for mulch, so local sources of organic waste must be evaluated in each district.

AMOUNTS OF VINEYARD AND WINERY WASTE AVAILABLE

As stated in the previous section, the volume of prunings and marc available from your own vineyard is likely to be a limiting factor when deciding to make mulch and apply it to your property.

Raw material available

Trial results obtained in 2000, 2001 and 2002 showed that the average weight of prunings from Sauvignon Blanc vines across the four vineyard trial sites was approximately four tonnes per hectare.

If 10 tonnes of Sauvignon Blanc grapes are harvested per hectare, approximately 7800 litres of clean juice is extracted (7800 kgs). The other 2200 kg is comprised of marc and soft lees, which is waste available for composting.

Per hectare, four tonnes of prunings and 2200 kg of grape marc is available per annum from Sauvignon Blanc grapevines.

Currently a number of vineyards are applying a composted mulch that comprises solely vineyard prunings and marc. The prunings and marc are mixed together in approximately a 3:1 or 2:1 volume ratio. The mixing ratio varies depending on the quantities available in a particular year.

Calculations of the weight and volume of the prunings and marc were performed in May 2002 (Table 13). The prunings had been stockpiled for approximately nine months and were at the stage of being mixed with current season's marc. A second sample of freshly chopped prunings was weighed in August 2002. It was clear that the percentage moisture content of the ingredients has a big influence on the weight of the composted mulch and can vary considerably according to how long the raw materials have been stockpiled. The weight of a known volume will also vary according to how much compaction has taken place.

Table 13. Weight and volume of grape prunings and grape marc (May 2002)

	Vineyard Prunings (fresh)	Vineyard prunings (9 months old)	Marc (fresh)	Composted Mulch Prunings+marc
10 litres (wet weight)	2.285 kg	2.360 kg	5.192 kg	4.529 kg
10 litres (dry weight)	1.332 kg	1.104 kg	1.677 kg	1.719 kg
Moisture	42 %	53 %	68 %	62 %
Dry Matter	58 %	47 %	32 %	38 %
Calculated volumes and weights from 10 litre samples				
1 cubic metre	228.5 kg	236.0 kg	519.2 kg	452.9 kg
1 tonne	4.38 m^3	4.24 m^3	1.93 m^3	2.21 m^3
4 tonnes prunings / ha	Yields 17.5 m^3			
2.2 tonnes marc / ha	Yields 4.25 m^3			

The weights shown in table 13 are based on loosely packed materials.

The mixture of prunings and marc goes through a composting process for a number of months prior to application. As the materials begin to break down, their bulk density increases. The total volume of material available decreases by about one-third during the composting process.

11

VINEYARD AREA REQUIRED TO PRODUCE THE RAW INGREDIENTS

Given an application rate of 55 m^3 of prunings + marc mulch per hectare, how many hectares of grapes are required to produce the raw ingredients?

The following is only a guideline. If your prunings and marc come from a fixed source then the amounts will vary from year to year and the ratio of mixing will probably also vary.

One hectare of Sauvignon Blanc grapes produces approximately four tonnes, or 17.5 m^3, of fresh prunings. However, the pruning chopper machine leaves a small amount of prunings behind and some is not blown into the collection wagon. Allowing for losses we have assumed that approximately 15 m^3 fresh prunings will be collected per hectare or about 3400 kg / ha.

Table 13 gives the weight and moisture content of fresh and nine-month-old grape prunings. The moisture content of the fresh prunings was actually considerably less than after storage for nine months. It is likely that the stored prunings dry out over the summer, however they probably reabsorb moisture over the winter. The moisture content of the stored prunings will vary considerably depending on time of year. For this reason we are making the assumption that the volume of prunings available for mixing is similar to that collected.

3:1 mixing ratio of prunings to marc
4 m^3 of freshly mixed mulch = 3 m^3 of prunings + 1 m^3 of fresh grape marc.

The mixed mulch undergoes approximately six months of composting prior to application to the vineyard in the spring. One third of this volume is lost during composting.

4 m^3 of fresh mulch, less one third volume (1.333 m^3) = 2.667 m^3 of composted mulch after 6 months.

Compost volume of 2.667 m^3. Two thirds of the compost volume is prunings, (1.778 m^3), and one third is marc (0.889 m^3).

55 m^3 compost applied to one hectare
Contains 41.25 m^3 composted prunings and 13.75 m^3 composted marc. (Still assumes 3:1)

However one-third of the volume of the ingredients has been lost during composting.
41.25 m^3 composted prunings comes from 61.88 m^3 fresh prunings (41.25 x 3/2 = 61.88).
13.75 m^3 composted marc comes from 20.63 m^3 fresh marc (13.75 x 3/2 = 20.63).

Area required to collect raw ingredients for 55 m^3 prunings + marc compost per hectare
Given that 15 m^3 fresh prunings are collected per hectare, it therefore takes 4.13 hectares of grapes to produce 61.88 m^3 prunings for one hectare of applied mulch.

Given that 4.25 m^3 fresh marc are collected per hectare it therefore takes 4.85 hectares of grapes to produce 20.63 m^3 marc for one hectare of applied mulch.

At a mixing ratio of 3:1 prunings to marc it takes 4.1 hectares to produce enough prunings and 4.85 hectares to produce enough marc.

This tells you that the minimum reapplication time for the mulch would be about five years.

12

COMPARATIVE COST OF PURCHASING OR MAKING MULCH, PER HECTARE

A number of Marlborough vineyards have chosen to purchase mulch. Some of the products have been composted, some have not. At the time of publication of this report one Marlborough company is offering a service to the viticultural industry. This is Hortro Spread, a division of Soil Bark and Coal Specialities.

A Richmond company, Bark Processors (2001) Limited, is also supplying rotted bark which a number of vineyards have chosen to apply.

Hortro Spread offers a number of alternatives in the making and application of mulch as follows:

- Making composted mulch incorporating vineyard waste streams. The mulch mix can be varied according to the requirements of the grower.
- Supply of ready made compost.
- Hireage of the mulch loader and spreader so that vineyards can apply the mulch themselves.
- Purchase and application of bark, from Bark Processors (2001) Limited, and other sources.

Approximate costs at November 2002 are:

- $40 per cubic metre for composted mulch.
- $23 per cubic metre for rotted bark delivered from Richmond ($15/m^3 + $8/m^3 transport).
- $500 to $1000 per hectare cost of application of mulch.

An indication of the cost of purchasing and applying mulch is given in Table 14.

Table 14. Cost of purchasing and applying mulch

Mulch Type	Rotted Bark	Rotted Bark	Compost	Compost
Purchase price/m^3	$23	$23	$40	$40
Application rate/ha	55m^3	85m^3	55m^3	85m^3
Application cost/ha	$750	$1000	$750	$1000
Total cost/ha	$2015	$2955	$2950	$4400
Cost per m vine row	$0.605	$0.887	$0.885	$1.32

Assumes a standard planting density of 3m * 1.8m = 1851 plants per ha or 3332 m of vine row per ha.

When making your own composted mulch it is assumed that it costs $30 per tonne to make the compost and that there are 2.2m^3 per tonne. An indication of the cost of making and applying your own composted mulch is given in Table 15.

Table 15. Cost of making your own composted mulch on site using prunings +marc

Mulch Type	Prunings + Marc	Prunings + Marc
Making compost/m^3	$13.60	$13.60
Application rate/ha	55m^3	85m^3
Making cost/ha	$748	$1156
Application cost/ha	$750	$1000
Total cost/ha	$1498	$2156
Cost per m vine row	$0.449	$0.647

Assumes a standard planting density of 3m * 1.8m = 1851 plants per ha or 3332 m of vine row per ha.

13

NUTRIENT COMPOSITION OF MULCHES

Nutrient analyses are performed either as total nutrients in a known weight of oven dry sample or as plant available nutrients that are soluble in water (Hill Laboratories Ltd.).

To calculate total nutrients applied (not all are available to the plant)

To find out the total amount of nutrients that are potentially being applied per hectare with a mulch, you need to send a sample of the mulch for analysis at the time of application. The sample will be analysed as miscellaneous compost. The laboratory will calculate the total nutrients based on the oven-dried weight, (g/100g). It will also report the moisture content of the sample you send. If you know the weight applied per hectare, the total nutrients applied can be converted from a dry matter basis to an “as received” basis using the moisture result. If you only know the total volume applied, you need to weigh a known volume (e.g. 10 litres) of freshly applied mulch and calculate the weight applied per hectare.

To calculate the total amount of nutrient applied, from the lab result use the following formula:

Result (dry matter basis x ((100-moisture%) / 100) = result (as received)

e.g. Table 16 for the rotted bark with total nitrogen of 0.38 g/100g dry weight and sample of 42.4 percent moisture
0.38 * ((100-42.4)/100) = 0.219 g N/100g of wet weight
Or 2.190 kg N / tonne of mulch applied (little of this nitrogen will be plant available)

Carbon/Nitrogen Ratio

The C/N ratio can be useful to assess the nitrogen supplying potential of the compost. In undecomposed organic matter the amount of carbon is relatively high and as it decomposes much of this is lost to the atmosphere as carbon dioxide. In this process nitrogen is consumed by microbes breaking down the organic carbon. A high C/N ratio usually means that very little nitrogen is available to the crop, because of this microbial competition. For growers relying on their nitrogen source being provided from the recycling of organic materials, this ratio can be used to judge whether the compost is likely to supply nitrogen, or in extreme cases, consume it in the breakdown of the material (Hill Laboratories 1998).

A compost is usually called mature when the C/N ratio is lower than 12. A C/N ratio higher than 25 leads to the immobilisation of mineral nitrogen (Deurer et al. 2000). However, if the compost is being placed on the soil surface and not incorporated into the soil then the immobilisation of mineral nitrogen in the soil will be minimised.

Tables 16 and 18 list nutrients as reported for a basic compost analysis. The nutrients are reported on a dry matter basis as determined by Hill Laboratories Ltd. and they are the total nutrients contained in the particular mulch. They are not the plant available nutrients.

13 CONT…

Table 16. Nutrients analysis of rotted bark

Bark as supplied from Bark Processors (2001) Limited, Richmond. Moisture at 42.4 %, giving dry matter of 57.6%.

Nutrient Composition	Rotted Bark Dry (kg/tonne)	Rotted Bark Wet (kg/tonne)	Rotted Bark Wet 55m³/ha (kg/ha)
Organic matter	600.0	345.6	13,306
C/N ratio	91:1		
pH		5.8	
Total nitrogen	3.8	2.19	84.32
Phosphorus	0.41	0.236	9.09
Potassium	1.07	0.616	23.72
Calcium	8.34	4.804	185.0
Magnesium	4.68	2.696	103.8
Sodium	0.27	0.156	6.01
Sulphur	1.30	0.749	28.84
Iron	15.2	8.755	337.1
Manganese	0.306	0.176	6.78
Zinc	0.0426	0.0245	0.94
Copper	0.0124	0.0071	0.27
Boron	0.0044	0.00025	0.01

The analysis as received from Hill Laboratories Ltd. reports nutrients as g/100g on a dry weight basis. g/100g x 10 = kg/tonne Dry weight

To convert the nutrients to a wet basis the formula used is: Dry matter * 0.576 = wet
1 tonne = 1.43 m³, or 1 m³ = 700 kg, therefore 55 m³ = 38.5 tonnes / ha

Table 17. Values of nutrients in rotted bark

Element		Fertiliser	Cost Per Tonne	% nutrient in fertiliser	Cost per Kg Nutrient in fertiliser	Kg nutrient per tonne compost (wet basis)	Value of Nutrient in Compost $/tonne Wet basis	Value of Nutrient in Compost At 55m³/ha Wet basis
N	as	Urea	$350	46	$0.76	2.19	$1.66	$64.08
N	as	CAN	$435	27	$1.61	2.19	$3.53	$135.75
P		Super P	$188	9.1	$2.07	0.236	$0.49	$18.82
K		Sulp of Potash	$634	43	$1.47	0.616	$0.91	$34.87
Ca		Ag lime	$40	38	$0.11	4.804	$0.53	$20.35
			Total nutrient value, nitrogen as urea				$3.59	$138.12
			Total nutrient value, nitrogen as CAN				$5.46	$209.79

There is a large amount of magnesium supplied in the bark, which if costed on a per kg basis as magnesium sulphate would have a high value. This has not been included in the total value as only a small amount of magnesium would normally be applied in an artificial fertiliser.

Table 18. Nutrient analysis of marc + prunings mulch

Moisture at 30.9 %, giving dry matter of 69.1%.

Nutrient Composition	Marc+Prunings Dry (kg/tonne)	Marc+Prunings Wet (kg/tonne)	Marc+Prunings Wet 55m³/ha (kg/ha)
Organic matter	833.0	575.6	14,327
Carbon/nitrogen ratio	68:1		
pH	7.4		
Total nitrogen	7.2	4.97	123.7
Phosphorus	1.9	1.313	32.68
Potassium	1.57	1.085	27.01
Calcium	8.48	5.86	145.9
Magnesium	2.17	1.50	37.34
Sodium	0.20	0.138	3.43
Sulphur	1.55	1.07	26.63
Iron	4.3	2.97	73.92
Manganese	0.098	0.068	1.69
Zinc	0.057	0.039	0.97
Copper	0.036	0.025	0.62
Boron	0.022	0.015	0.37

The analysis as received from Hill Laboratories Ltd. reports nutrients as g/100g on a dry weight basis. g/100g x 10 = kg/tonne Dry weight

To convert the nutrients to a wet basis the formula used is: Dry matter * 0.691 = wet
1 tonne = 2.21 m³, or 1 m³ = 452 kg, therefore 55 m³ = 24.89 tonnes/ha

Table 19. Values of nutrients in marc + prunings mulch

Element	Fertiliser	Cost Per Tonne	% nutrient in fertiliser	Cost per Kg Nutrient in fertiliser	Kg nutrient per tonne compost (wet basis)	Value of Nutrient in Compost $/tonne Wet basis	Value of Nutrient in Compost At 55m³/ha Wet basis
N as	Urea	$350	46	$0.76	4.97	$3.78	$94.01
N as	CAN	$435	27	$1.61	4.97	$8.00	$199.16
P	Super P	$188	9.1	$2.07	1.313	$2.72	$67.65
K	Sulp of Potash	$634	43	$1.47	1.085	$1.59	$39.71
Ca	Ag lime	$40	38	$0.11	5.86	$0.64	$16.05
			Total nutrient value, nitrogen as urea			$8.73	$217.42
			Total nutrient value, nitrogen as CAN			$12.95	$322.57

14

POSSIBLE COST SAVINGS ASSOCIATED WITH THE USE OF MULCH

14.1 Reduction in irrigation applied

The ability to retain soil moisture in the early part of the season was demonstrated in section one. More than four weeks delay in the drop in soil moisture levels under mulch was found.
If it is assumed that due to higher moisture levels under mulch, the onset of irrigation could be delayed by four weeks, and in a dry season the vines may receive five litres of water per day in the early part of the season, then:

1851 plants/hectare x 5 litres/plant/day x 28 days = 259,140 litres water saved = 259.1 m^3/hectare

At present the only cost saving to be made from a reduction in irrigation is through less electricity being used for pumping. Estimated current costs for electricity and pump maintenance are from 6 to 10c per cubic metre of water. Cost savings through a reduction in irrigation applied have been estimated as follows:

It is likely that water supplied through proposed irrigation schemes in Marlborough will cost a minimum of 10c per cubic metre:

10c/m^3 x 259.1m^3/ha = $25.91/ha

14.2 Reduction in fertiliser use

14.2.1 Fertiliser costs in a conventional vineyard

Estimates of fertiliser costs derived from a company vineyard are:

Fertiliser cost	$	117	/ha/year
Spreading cost	$	5	/ha/year
Cartage cost	$	4	/ha/year
Total cost	$	126	/ha/year

The fertiliser cost takes into account the cost of fertigation and also lime, if and when it is required.

From Table 19 it can be estimated that the total nutrient value in a marc + prunings mulch when applied at 55 m^3/ha to be a maximum of $322/ha. However, given that the reapplication time of the mulch is likely to be five years, then the nutrient value is $322/5 = $64.40/ha/year.

14.3 Reduction in herbicide usage

The trial work has shown that use of a relatively deep mulch leads to a reduction in the number of herbicide applications that are necessary to control weeds. In a commercial vineyard the mulches applied are unlikely to be as deep as in the trials. The weed suppressive ability of the mulch is probably most likely to be gained in the first and possibly second year after application. Length of time will depend on the initial depth of mulch and its subsequent breakdown.

Table 20. Costs per hectare of a common herbicide schedule on a company vineyard.

Herbicide	Application rate and $/litre	Chemical cost	Application cost	Total cost
Amitrole in spring	$11/litre & 4 litres/ha	$44	$30	$74
Buster in summer	$25/litre & 5 litres/ha	S125	$30	$155
Glyphosate	$ 9/litre & 4 litres/ha	$36	$30	$66
Total Costs		$205/ha	$90/ha	$295/ha

The application cost is based on a contract spraying rate.
The total cost per season for three herbicide sprays is approximately $295 per hectare and considerable savings can be made by dropping even one spray application.

The reality is that one property, where mulch was applied in 2001, used four herbicide sprays on their unmulched areas in the 2001/2002 season, whereas the mulched areas received only one herbicide spray. If it is assumed that by using a marc + prunings mulch that four herbicide applications could be saved over the five year reapplication time for the mulch then there is a minimum saving of $264 per hectare (four glyphosate sprays). This is a saving of $52.80/ha/year.

14.4 Possible reduction in the use of diammonium phosphate (DAP) supplements in the winemaking process

In cases where yeast available nitrogen is low in the grape juice, diammonium phosphate has to be added to the fermentation to avoid what are called stuck or sluggish ferments. Results obtained from the trial work in Marlborough suggest that the use of mulch containing significant amounts of nitrogen can raise the yeast available nitrogen in the grape juice. This should negate the need to add DAP to the juice.

At 10 tonnes grapes / ha and 8000 litres of juice, a saving could be made of 4 kg of DAP (commonly added at 0.5 g/l), or $24 per hectare (DAP at $6 / kg).

The potential cost savings may seem very small. However there is also a large opportunity cost associated with avoiding stuck ferments, which is difficult to quantify. A stuck ferment means that the juice is going to spend longer being fermented and that tank space will be tied up longer. It also means more work for winery staff.

Experiments conducted in Western Australia in the mid-1980s demonstrated that the addition of large amounts of nitrogen to the must at the start of fermentation in the winery were able to reduce the fermentation time. However the fermentation time was still higher than for fruit with vineyard derived nitrogen. The conclusion was that an adequate supply of nitrogen in the vineyard was required before a trouble-free fermentation was guaranteed. Higher yeast available nitrogen in the must was also associated with an improved wine flavour (Goldspink, 2001).

15

SUMMARY: COSTS OF APPLYING MULCH AND POTENTIAL SAVINGS

Minimum cost to make and apply mulch

\$1500/ha to apply 55 m^3 mulch. Or \$0.45 per metre of vine row (Table 15). From data collected in Marlborough, from Sauvignon blanc grapevines, there is a minimum reapplication interval of five years due to the raw materials available. Assuming that you reapply the mulch once every five years you need to divide \$1500 by five to obtain the annual cost per hectare.

Cost of making and applying a prunings + marc mulch, made on your own vineyard is \$300/ha/year

Possible cost savings determined in Marlborough research trials:

1 month delay in irrigation onset	\$25.91/ha/year
Herbicide saving of \$264/ha over 5 years	\$52.80/ha/year
YAN saving of	\$24.00/ha/year
Fertiliser saving of \$322/ha over 5 years	\$64.40/ha/year

Possible cost savings of **\$167 /ha/year**

Currently a large proportion of the grape marc produced in Marlborough is fed to stock. The cost of disposal is normally paid for by the purchaser of the marc, therefore the winery avoids this cost. There is a potential cost saving on disposal of this waste. If grape marc was to be disposed of at the Marlborough District Council landfill the cost would be \$12/m^3. It was reported in section 10 that Sauvignon Blanc grapes in Marlborough produce approximately 2.2 tonnes of grape marc, or 4.25 m^3 per hectare per year.

4.25 m^3/ha x \$12/m^3 = \$51/ha/year cost to dispose of grape marc at landfill.

It is clear that the cost of making and applying mulch currently outweighs the potential cost savings that could be gained from the use of mulch. However there are some other potential benefits that are difficult to quantify in economic terms such as: the opportunity cost in the winery associated with avoiding stuck ferments, possible improvements in wine quality with naturally derived yeast available nitrogen, a reduction in plant stress through more even soil temperature, improvements in soil structure and increases in soil organic matter over time, and improvement in soil health through an increase in soil micro-organisms.

IT NEEDS TO BE EMPHASISED THAT THE PRIMARY FACTORS FOR VINEYARDS DECIDING TO APPLY MULCH ARE NOT ECONOMIC. MOST OF THE VINEYARDS CURRENTLY USING MULCH ARE DOING SO TO MAKE THEIR VINEYARD PRACTISES MORE SUSTAINABLE IN THE LONG TERM.

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Annie McDonald and Mark Wheeler
Marlborough District Council

MULCH
FOR SUSTAINABLE PRODUCTION

> MULCHES IN VINEYARDS ARE SUCCESSFUL AND HAVE MANY BENEFITS.

> FOR AN INDUSTRY LOOKING FOR SUSTAINABLE PRACTICES, MULCHING IS ANOTHER TOOL TO BE ADDED TO VINEYARD BEST PRACTICES TO IMPROVE SOIL HEALTH, INCREASE MOISTURE RETENTION AND INITIALLY SAVEON THE USE OF HERBICIDES.

> MORE THAN EIGHT MARLBOROUGH VINEYARDS ARE NOW USING MULCHING AS PART OF THEIR CURRENT PRACTICES.

> ONE LOCAL COMPANY HAS SET UP A COMMERCIAL ENTERPRISE TO MIX AND SPREAD MULCHES ONTO VINEYARDS.

> THIS INFORMATION ON MULCHES FOR SUSTAINABLE PRODUCTION IS NOT ONLY VALUABLE TO THE WINE INDUSTRY, BUT CAN BE USED BY MANY OTHER LAND-BASED INDUSTRIES.

> THE USE OF MULCH AS A SUSTAINABLE VINEYARD PRACTICE ENHANCES THE BRAND POSITIONING STATEMENT OF NEW ZEALAND WINEGROWERS: "NEW ZEALAND WINE - THE RICHES OF A CLEAN GREEN LAND."

For general information about this programme contact the Marlborough District Council, Blenheim. (03) 578 5249

The booklet can be viewed on the Marlborough District Council web site. www.marlborough.govt.nz

For technical information contact:
HortResearch Marlborough
ragnew@hortresearch.co.nz
dmundy@hortresearch.co.nz
www.hortresearch.co.nz