

**THE CARBON DIOXIDE BUDGET  
OF THE NEW ZEALAND GRAPE  
AND WINE INDUSTRY**

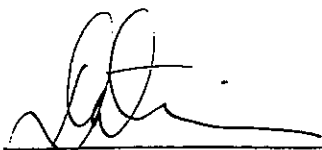
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## **EXECUTIVE SUMMARY**

### **Grape Production**

The 6015 hectares of vineyards in New Zealand are estimated to fix a net 9.7 tonnes per hectare per year of CO<sub>2</sub> from the atmosphere. This equates to a national total of 58300 tonnes.

### **Wine Production**

The processing of grapes into wine is responsible for an estimated net emission of 1.3 tonnes per hectare per year of CO<sub>2</sub> equating to a national total of 7700 tonnes.

### **Winery Waste Management**

Treatment of winery wastes results in an estimated net emission of 0.6 tonnes per hectare per year of CO<sub>2</sub> equating to a national total 3550 tonnes.

### **Overall carbon dioxide budget**

On an industry wide basis there is an estimated net fixation of 7.8 tonnes per hectare per year of CO<sub>2</sub>. Nationally, this equates to approximately 47000 tonnes of CO<sub>2</sub> being removed from the atmosphere every year. Increases in soil humus under a permanent cover crop account for more than half the CO<sub>2</sub> fixation and illustrate the importance of management practises on the environmental impact of vineyards in New Zealand.

## INTRODUCTION

As with all plant based activities the grape and wine industry is dependent upon the fixation of atmospheric carbon dioxide (CO<sub>2</sub>) through photosynthesis to produce biomass. During the processes of grape production and winemaking, however, CO<sub>2</sub> from various origins is also emitted into the atmosphere. The object of this submission is to approximately quantify the relative proportions of CO<sub>2</sub> fixation and emission by grape and wine production. Three areas will be treated as being the major components of the overall CO<sub>2</sub> balance: grape production, wine production, and winery waste management before an overall budget is estimated.

## GRAPE PRODUCTION

From details published in the New Zealand Vineyard Survey (Horner et al., 1996) the total New Zealand vineyard area in production for winegrapes in 1996 is 6015 ha. This figure will form the basis for national CO<sub>2</sub> budget calculations. Average grape yield over the last 10 years was 11.4 tonnes per hectare (Wine Institute of New Zealand Annual Report, Year Ended June 1996). Other components of the estimation of carbon fixation by moderately vigorous grapevines (Table 1) have been taken from data recorded by the following authors: Dugast, 1894, Muntz 1895, Lafon et al. 1966 and Champagnol 1984. These data have been adjusted to correlate with the average grape yield in New Zealand.

**Table 1. Estimated annual dry matter partitioning for moderately vigorous grapevines in New Zealand.**

grapevine organs	partitioning of net photosynthesis as dry matter (tonnes per hectare)
leaves	1.8
shoots	1.5
trunk and root growth	0.4
grape skins, seeds and lees	0.5
grape juice soluble solids	2.0
<b>total</b>	<b>6.2</b>

The above table shows that an average of 6.2 tonnes per hectare (t/ha) of dry matter is produced annually by grapevines. The partitioning of dry matter is in the order of 30% in leaves, 24% in shoots and 40% in grapes (skins, seeds, lees and must soluble solids) with only a small proportion (6%) being retained by the plant for annual growth after pruning. The dry matter is essentially composed of carbohydrates containing approximately 2.5 t/ha of elemental carbon. This equates to the net fixation of 9.1 t/ha of CO<sub>2</sub> per year.

Note: Total CO<sub>2</sub> absorption and subsequent re-emission through photorespiration, anaerobic glycolyse and other respiratory processes have not been presented as the balance of these metabolisms is the total accumulated dry matter at the end of each growth cycle.

Under normal vineyard management in New Zealand, leaves, trimmings and prunings are mulched back into the soil. Microbial activity returns approximately 45 % (Delas 1977) of carbon present in pruning wood and leaves to soil as humus (1.4t/ha/year of dry matter). By difference, the carbon converted into atmospheric CO<sub>2</sub> by micro-organisms is therefore 2.8 t/ha/year.

Studies have shown that permanent grassing of between vine rows (which is the standard practise in most New Zealand vineyards) results in increases in soil organic matter. Long term studies in French vineyards (Ancel 1983, Soyer et al., 1984) show annual increases in soil humus of 0.06 to 0.1 %. This equates to fixation of 3.0 to 5.0 tonnes of CO<sub>2</sub> per hectare per year. This increase in soil humus also infers that the use of chemical fertilisers is largely unnecessary except in rare cases where nutrient imbalances are obvious. No cost in CO<sub>2</sub> emissions from the fabrication of chemical or organic fertilisers needs therefore to be included in the CO<sub>2</sub> budget.

The CO<sub>2</sub> emissions involved in the fabrication of agrochemicals are difficult to estimate. It must be remembered however, that vineyards are low users of synthetic agrochemicals, these generally being limited to one insecticide application, two to four fungicide applications and localised herbicide spraying at the base of the vines. The balance of the fungicidal cover is obtained through the use of non-synthetic products largely copper sulphate and organic sulphur.

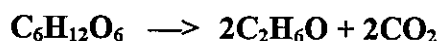
For one hectare of vineyard, the average tractor use is in the order of 22 hours per year (comm. pers. M. Insley Montana Wines) with diesel consumption averaging less than 7 litres per hour for spraying, mowing and trimming (Financial Budget Manual). The Carbon-Hydrogen ratio in diesel fuel at a density of 0.77 is on average C<sub>n</sub>-H<sub>2n</sub> (comm. pers. B.P. Technical Services). From these values it can be estimated that emission of CO<sub>2</sub> after combustion is a maximum of 2.4 kg per litre. The use of fossil fuels in tractors and sprayers would therefore generally be inferior to 0.37 t/ha/an. Mechanical harvesting emissions could be estimated at a maximum of 0.13 t/ha/an of CO<sub>2</sub> remembering, however, that hand harvesting is often practised for premium wine styles.

**Table 2. Net annual budget of atmospheric carbon dioxide (in tonnes) for New Zealand vineyards.**

	<b>Fixation</b>	<b>Emission</b>	<b>Balance</b>
grapevines	-54 700	11 400	-43 300
cover crops	-18 000	0	-18 000
fertilisers	0	0	0
agrochemicals	0	0	0
fossil fuels	0	3 000	3 000
<b>Total</b>	<b>-72 700</b>	<b>14 400</b>	<b>-58 300</b>

## WINE PRODUCTION

The principal process involved in the production of table wines is alcoholic fermentation. Yeasts transform one molecule of sugar into two molecules of ethanol and two of carbon dioxide (Gay Lussac (1778-1850) In : Peynaud et al., 1964).



The production of CO<sub>2</sub> for 2.0 tonnes per hectare of grape sugar (Table 1) is therefore 0.98 tonnes. Still wines can contain 400-1500 mg/l of dissolved CO<sub>2</sub> (Peynaud et al., 1964) while for sparkling wines the proportions are considerably greater. It would be reasonable to assume the New Zealand wines contain (on average) 1000 mg/l of dissolved CO<sub>2</sub>. This equates to less than 0.01 tonnes of CO<sub>2</sub> per hectare.

A secondary fermentation resulting in the transformation of malic acid into lactic acid produces 1 molecule of CO<sub>2</sub> for each molecule of malic acid transformed (In : Peynaud et al. 1964)



For an estimated average concentration in musts of 8g/l of malic acid this equates to the production of 0.02 tonnes of CO<sub>2</sub> per hectare but less than half the wines produced in New Zealand would undergo this secondary fermentation.

The vast majority of winery equipment is powered either by a 3 phase mains power supply or by compressed air from electric compressors. Generally no fossil fuels are consumed during the winemaking process as such. At some stage of the production chain however, the major proportion of the country's grape harvest is transported to Auckland in the form of either grape juice or wine for additional processing (i.e. crushing, fermentation, bottling, packaging or redistribution). A very approximate estimate would suggest that eventually 90% of the total tonnage is transported by road an average of 770 km to Auckland while the balance would be transported less than 50 km. An average transport distance could therefore be in the vicinity of 750 km or 30 kg of emitted CO<sub>2</sub> per tonne of grapes. The CO<sub>2</sub> emission costs of wine attaining export markets have not been included in this report as these would appear to fall outside the scope of any proposed legislation.

As for agrochemicals the carbon cost involved in the production of wine additives and production consumables (oak barrels, corks etc..) is difficult to estimate. Additives and consumables of non agricultural origin would appear sufficiently low to permit exclusion of CO<sub>2</sub> emissions associated with their production from the overall budget.

**Table 3. Net annual budget of atmospheric carbon dioxide (in tonnes) for New Zealand wineries.**

	Fixation	Emission	Balance
alcoholic fermentation	-60	5 900	5 840
malolactic fermentation	0	60	60
additives and packaging	0	0	0
fossil fuels	0	1 800	1 800
<b>Total</b>	<b>-60</b>	<b>7 760</b>	<b>7 700</b>

## WINERY WASTE MANAGEMENT

Winery wastes consist mainly of solid wastes (pomace and lees) and waste water. When solid wastes are reincorporated back into the soil, an average 65 % of the carbon content forms humus (0.3t/ha/year). The CO<sub>2</sub> emissions associated with the biodegradation of pomace and lees are by difference approximately 0.3 tonnes/ha/year. On average 4 tractor hours per hectare are required to reincorporate solid wastes resulting in the total emission of 400t/yr of CO<sub>2</sub>.

Wineries produce waste water at a rate of approximately 3 cubic metres per tonne of grapes processed (Jacobson et al. 1996). This waste water which contains predominately carbohydrates has a maximum biological oxygen demand (BOD) of 5000 mg/l (Marlborough District Council 1995) and 95 % of the dissolved organic matter is converted into atmospheric CO<sub>2</sub> (Chapman 1994). These figures suggest that total CO<sub>2</sub> emissions for the treatment of winery waste water are in the vicinity of 0.225 t/ha/year.

**Table 4. Net annual budget of atmospheric carbon dioxide (in tonnes) for New Zealand winery waste water.**

	<b>Fixation</b>	<b>Emission</b>	<b>Balance</b>
solid wastes	0	1 800	1 800
waste water	0	1 350	1 350
fossil fuels	0	400	400
<b>Total</b>	<b>0</b>	<b>3 550</b>	<b>3 550</b>

## OVERALL CARBON BUDGET

**Table 5.** Net annual budget of atmospheric carbon dioxide (in tonnes) in the New Zealand grape and wine industry.

	<b>Fixation</b>	<b>Emission</b>	<b>Balance</b>
grape production	-72 700	14 400	-58 300
wine production	-60	7 760	7 700
winery waste management	0	3 550	3 550
<b>Total</b>	<b>-72 760</b>	<b>25 710</b>	<b>-47 050</b>

On an industry wide basis nearly three times the amount of CO<sub>2</sub> is removed from the atmosphere as is emitted (Table 5). On a per hectare basis this equates to an estimated theoretical net fixation of 7.8 tonnes of CO<sub>2</sub> per year.

In reality this figure will vary considerably from vineyard to vineyard, particularly with respect to soil management practises. The preceding values have been calculated for a vineyard in which a permanent cover crop is grown between every row of vines. In a bare soil situation, the level of fixation of CO<sub>2</sub> would be more than halved to approximately 3.8 tonnes per hectare per year. If prunings are burnt, rather than being mulched back into the soil, there would be a further 0.6 tonne per hectare decrease in CO<sub>2</sub> fixation. These figures, although estimates calculated from overseas data, illustrate the importance of management practises on the environmental impact of vineyards in New Zealand. It should be recognised, however, that research into the effects of vineyard management practises on soil organic matter levels must be carried out under local conditions to validate any estimations.

As the current estimate of the overall CO<sub>2</sub> budget is an atmospheric deficit of approximately 47 000 tonnes per annum, no form of tax on CO<sub>2</sub> emissions would seem appropriate. With total producing vineyard area predicted to expand more than 20 % over the coming 3 years (Horner et al. 1996) the amount of atmospheric CO<sub>2</sub> fixed will increase proportionally.

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