

Apple and cherry orchards low nitrous oxide emissions – plenty to smile about

Orchard soil management and going to the dentist have something in common – nitrous oxide.

We all appreciate the benefits of nitrous oxide or “laughing gas” in the dentist’s chair. But in the orchard nitrous oxide produced from the soil is no laughing matter.

Nitrous oxide is a serious pollutant

Nitrous oxide is a serious pollutant contribution to both increases in atmospheric greenhouse gases and ozone depletion. As a greenhouse gas, nitrous oxide has more than 300 times the warming potential of carbon dioxide. Agriculture is responsible for almost 75% of nitrous oxide emissions¹. Nitrous oxide is also now the most significant ozone destroying pollutants, increasing the levels of ultraviolet radiation and the risk of skin cancers.²

Nitrous oxide emissions measured in NSW and Tasmania orchards

AHR and the Tasmanian Institute of Agriculture measured soil nitrous oxide emissions from two commercial apple (Orange, NSW and Lucaston, Tasmania) and two cherry orchards (Young, NSW and Lower Longley, Tasmania) in a study funded by Horticulture Innovation Australia and the Federal Department of Agriculture and Water Resources.

This factsheet summarises the first Australian study of nitrous oxide emissions from apple and cherry orchards.³

¹ Australian Greenhouse Office (AGO) (2001) ‘National greenhouse gas inventory 1999 with methodology supplements.’ (AGO: Australia)

² Portmann, R.W., Daniel, J.S., Ravishankara, A.R. Stratospheric ozone depletion due to nitrous oxide: Influences of other gases (2012) Philosophical Transactions of the Royal Society B: Biological Sciences, 367 (1593), pp. 1256-1264.

³ Nigel Swarts, Kelvin Montagu, Garth Oliver, Liam Southam-Rogers, Marcus Hardie, Ross Corkrey, Gordon Rogers and Dugald Close. 2016. Benchmarking nitrous oxide emissions in deciduous tree cropping systems. Soil Research 54:500-511.

Take home messages

- Nitrous oxide produced from agricultural soils is a serious pollutant contributing to increases in atmospheric greenhouse gases and ozone depletion.
- Measurements in apple and cherry orchards in NSW and Tasmania have shown very low annual soil nitrous oxide emissions ranging between 0.3 to 0.7 kg N₂O-N ha⁻¹ year⁻¹
- The low emissions were due to low nitrogen fertiliser use, cool temperate growing conditions and micro-irrigation systems in the orchards
- Higher nitrous oxide emissions from the grassed alleys were a surprise and indicated that emissions could be even lower
- The emissions intensities, that is, emissions per tonne of fruit, were very low in both apples and cherries, due to good yields and the low nitrous oxide emissions.



Apple and cherry orchards low nitrous oxide emissions



Low nitrous oxide emissions measured in orchards

In a great result for the orchards, the annual soil nitrous oxide emissions were a very low at 0.3 to 0.7 kg N₂O-N ha⁻¹ year⁻¹ (Figure 1). These low emissions were achieved with nitrogen fertiliser rates ranging from 15 to 200 kg N ha⁻¹, giving the apple and cherry industry something to smile about.



Figure 1: Annual nitrous oxide emissions from the soil of apple and cherry orchards in Tasmania and NSW

These values are very low compared with other cropping systems. For example, nitrous oxide emissions from apple orchards in China have been reported to be between 3.2 and 44.3 N₂O-N ha⁻¹ year⁻¹;⁴ and for Californian grapes between 0.6-3.9 kg N₂O-N ha⁻¹ year⁻¹.⁵

Low nitrous oxide emissions are a win for the environment due to the potent greenhouse impact of nitrous oxide. Nitrous oxide stays in the atmosphere for more than 100 years, with one tonne of nitrous oxide equivalent to 298 tonnes of carbon dioxide when it comes to global warming potential. By keeping nitrous oxide emissions low, growers are permanently reducing their greenhouse impact.

Low nitrous oxide emissions are a win for health reasons too. Nitrous oxide is also an ozone destroyer, more important than CFCs and unregulated by the Montreal Protocol.⁶ The process that removes nitrous oxide from the atmosphere also depletes atmospheric ozone. Ozone depletion allows more ultraviolet radiation through to the earth and can damage humans, plants and animals. Skin cancer is already a disease of epidemic proportions in Australia, which has the world's highest incidence of the most lethal form of skin cancer. It is estimated that for every 1% decrease in ozone, there could be a 4 to 6% increase in skin cancers.⁷



Reducing nitrous oxide emissions also improves farm productivity. Nitrous oxide emissions are nitrogen fertiliser lost. While the direct amount of nitrogen lost via nitrous oxide is small, ranging from 0.3 to 0.7 kg N₂O-N ha⁻¹ year⁻¹, nitrous oxide is an indicator of overall gaseous losses, which can be 40 times that of nitrous oxide. This would mean that, potentially, 12 to 28 kgN ha⁻¹ was lost during the year. Reducing these losses improves the use and value of nitrogen fertiliser and has environmental and health benefits.

Good water and nitrogen the key to keeping nitrous oxide emissions low

The low emissions found in this study are due to good management of irrigation and nitrogen fertiliser in the orchards.

The orchards used frequent low-intensity irrigation using under-tree drip or micro-sprinkler systems. This minimises waterlogging and subsequent anaerobic soil conditions, reducing the likelihood of nitrous oxide emissions.

Fertigation also helps to lower further the risk of nitrous oxide emissions. By multiple split nitrogen fertiliser applications, which are only practical with the use of fertigation, nitrogen supply can be closely matched to the nitrogen requirement of the trees. As a result, mineral nitrogen does not build up in the soil. And without lots of nitrate, nitrous oxide emissions will be low.



Chambers used to measure nitrous oxide emissions from the soil in apple/cherry orchards.

⁴ Pang JZ, Wang XK, Mu YJ, Ouyang ZY, Liu WZ (2009) Nitrous oxide emissions from an apple orchard soil in the semiarid Loess Plateau of China. *Biology and Fertility of Soils* 46, 37–44.

⁵ Garland GM, Suddick E, Burger M, Horwath WR, Six J (2014) Direct N₂O emissions from a Mediterranean vineyard: event-related baseline measurements. *Agriculture, Ecosystems & Environment* 195, 44–52.

⁶ Ravishankara, AR., Daniel, JS., and Portmann, RW., (2009). Nitrous Oxide (N₂O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century. *SCIENCE* 326, 123-125.

⁷ Beder, S., (1992). *The Hole Story: Ozone Depletion Research in the Areas of Medical, Biological and Veterinary Science*. Physics, Pharmacy and Physiology. Sydney University.

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Higher nitrous oxide emissions from the grassed alleys a surprise

Two-thirds of the annual nitrous oxide emissions were from the grassed alleys. This was unexpected as nitrogen fertiliser and irrigation was only applied to the tree rows. The high nitrous oxide emissions from the grassed alleys suggest that emissions could be further reduced.

The biggest surprise from the study is that two-thirds of the nitrous oxide emissions were from the grassed alley (Figure 1). As nitrogen fertiliser and irrigation was applied only to the tree line, greater nitrous oxide emissions would have been expected from the tree line. The already low nitrous oxide emissions could be lowered by changing the management of the grassed alley.

Emissions intensity

Increasingly, emissions intensity is being used to compare agricultural practices and the greenhouse emission profile of agricultural products around the world. Emissions intensity converts nitrous oxide emissions into carbon dioxide equivalents ($\text{CO}_{2\text{eq}}$) and expresses the emissions per tonne of product i.e. $\text{kg CO}_{2\text{eq}} \text{ Tonne}^{-1}$.

Having low emissions intensity could become a competitive advantage as the world moves to reducing greenhouse gas emissions. So how do the emissions intensity of Australian apples and cherries stack up? The emissions intensities of both apples and cherries were low, due to good yields and low nitrous oxide emissions (Figure 2).

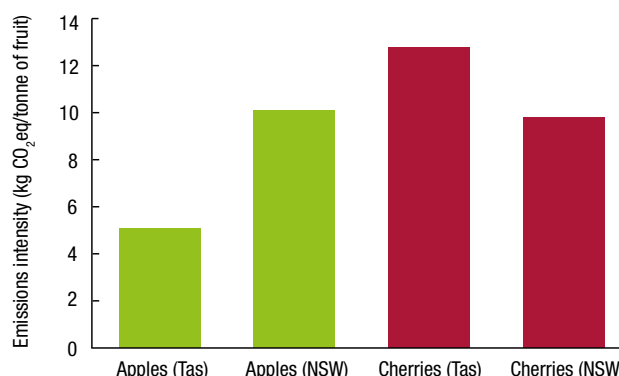


Figure 2: Emissions intensity for Tasmanian and NSW grown apples and cherries. Emissions intensity expresses the amount of nitrous oxide emissions (converted into carbon dioxide equivalent) for each tonne of fruit produced.

Nitrous oxide emissions from orchards – plenty to smile about

Australian apple and cherries growers have plenty to smile about when it comes to nitrous oxide. Good yields and low nitrous oxide emissions from the orchards measured result in apples and cherries having world leading emissions intensity.

This is a win for the environment, grower health, fertiliser productivity and the environmental credentials of their fruit crops.