SoilWealth
NURTURING CROPS

# Nitrous oxide emissions from vegetable soils

## What's all the fuss about?

Nitrogen is a key input into vegetable production. Applying high levels of nitrogen, either as fertiliser, compost or amendments is necessary to achieve high yields, but it can also result in nitrous oxide gas being released into the atmosphere.

Nitrous oxide is a powerful greenhouse gas and is responsible for the majority of emissions from the Australian vegetable industry after $CO_2$, associated with electricity production for cooling and pumping.

### Loss of plant available nitrogen

Nitrous oxide ($N_2O$) gas is produced by soil bacteria. The highest emissions occur when the soil is low in oxygen because under these conditions, bacteria use oxygen from nitrate ($NO_3$-), converting it to nitrous oxide and also to nitrogen gas ($N_2$) through denitrification.

This conversion is at the expense of plant available nitrogen, representing a waste of nitrogen fertiliser.

Nitrous oxide emissions can also be used as an indicator of plant available losses of nitrogen through denitrification.

### Nitrous oxide is a serious pollutant

Nitrous oxide is a serious pollutant. As a greenhouse gas, it has 300 times the warming potential of carbon dioxide[1] and adding to the level of gases in the atmosphere, which can trap heat. Nitrous oxide is also the most significant ozone destroying pollutants.[2]

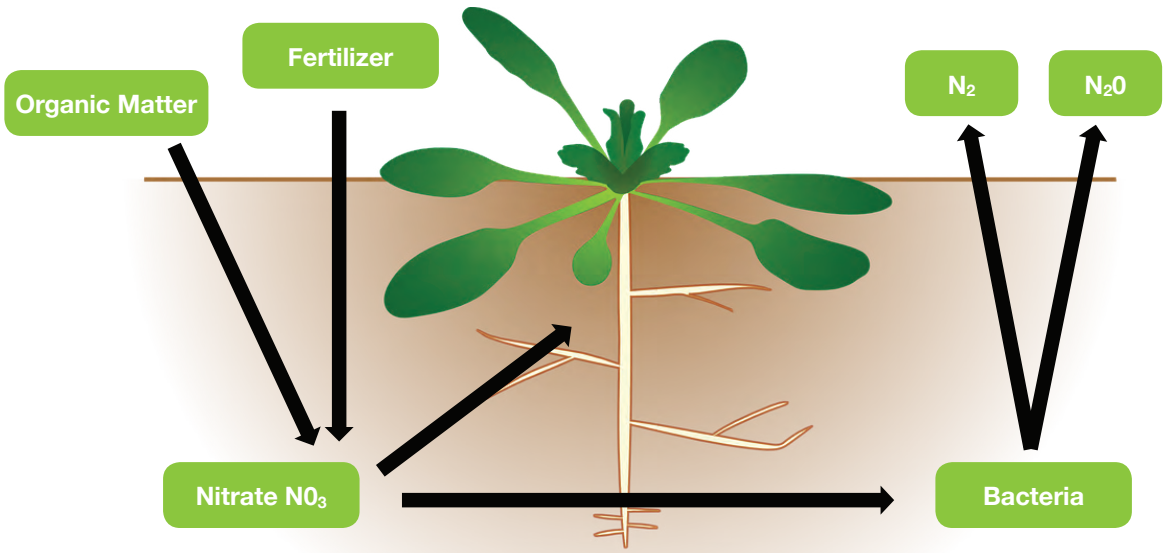


**Figure 1: Simplified nitrogen cycle in vegetable soils.**

[1]Rezaei Rashti, M., Wang, W., Moody, P., Chen, C., Ghadiri, H. Fertiliser-induced nitrous oxide emissions from vegetable production in the world and the regulating factors: A review (2015) Atmospheric Environment, 112, pp. 225-233.

[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.

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# Nitrous oxide emissions from vegetable soils

## How to reduce $N_2O$ emissions from vegetable soils

### It's a summer issue

Soil temperature has a major impact on the activity of soil bacteria, which produce nitrous oxide emissions. As a "rule of thumb", nitrous oxide emissions are low when the soil temperature is below 15°C.

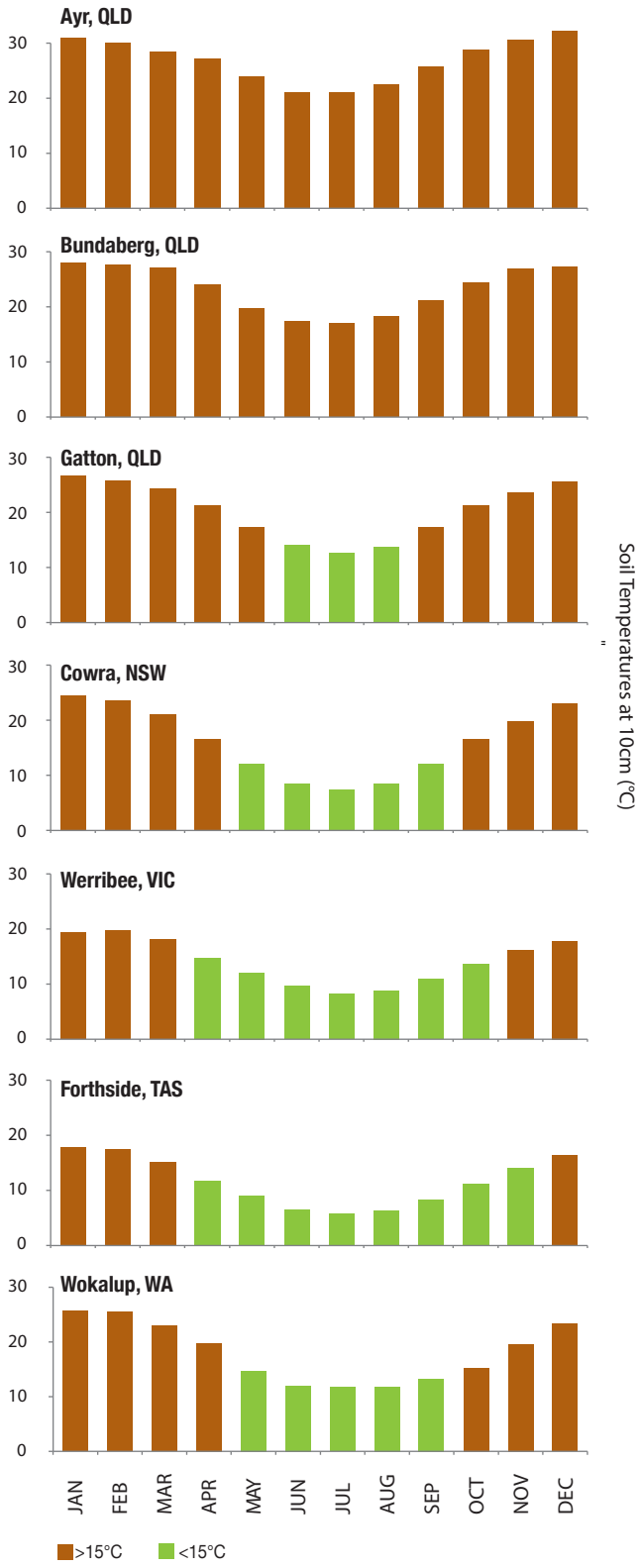
For most vegetable growing areas this reduces the risk of emissions to late spring-summer-early autumn. Figure 2 shows typical soil temperatures in your region over the year. The brown bars represent the danger times.

## Water – the key to managing emissions

Water is a key driver in vegetable farms, and effective irrigation management can reduce N losses through both $N_2O$ emissions and nitrate leaching. $N_2O$ emissions increase when the soil is wet, either through rainfall or heavy irrigations.

To reduce the risk of $N_2O$ emissions, nitrogen fertilisers should be applied at least a week after rainfall or irrigation. Tillage under wet conditions should also be avoided.

**Figure 2: Soil temperatures in major vegetable growing areas**



## Nitrogen management: The 4 R's[3]

Fertiliser is a cost to production; the more efficiently it is applied and used by the crop the better for production, profitability and the environment.

1. **Right Product** – Under wet soil conditions, nitrate in the soil is converted to oxides of N and $N_2$. It follows that $N_2O$ emissions are less where ammonium ($NH_4+$) is the dominant form of N and its rate of conversion to $NO_3-$ in the soil is slowed. Nitrification inhibitors can slow the conversion of $NH_4+$ to $NO_3-$ but the price and logistics need to be considered.
2. **Right Rate** – The optimum N fertiliser rate depends on the crop and the system in which it is growing. Nitrous oxide emissions may only be small component of overall N losses from wet soils. It makes sense to consider the other sources of N supply, type of fertiliser, logistics, cost, crop requirements and N emissions when deciding on the appropriate fertiliser application rate. $N_2O$ emissions are more likely when the supply of nitrate in the soil is greater than required by a crop.
3. **Right Time** – Matching fertiliser application to crop demand makes best use of this resource. Limit pre-planting N and add N during the crop if possible or use slow release fertilisers – know your crops N uptake pattern.
4. **Right Place** – Placing the fertiliser in the active root zone is optimal.

**Add organic matter to the soil but don't apply nitrogen fertiliser at the same time.**

Adding organic matter is great for the soil but is does increase the risk of nitrous oxide emissions. Soil bacteria feed on soil organic matter, and they need oxygen to process this food, just like we do. When large amounts of organic matter are added, the heightened bacteria activity can use up all the available oxygen and force soil bacteria to look for alternative sources of oxygen. One source is the oxygen associated with nitrate, resulting in nitrous oxide emissions and nitrogen losses through denitrification.

[3] Best Management Practices to Reduce Nitrous Oxide Emissions for Annual Vegetable Production. Gerard Fullerton, Chris Dowling, Jeff Kraak, George Rayment, Julio Vargas, Ash Wallace & Charlie Walker.

### Take home messages

- **Nitrous oxide losses can be controlled with good management**
- **Water logged soil will have higher $N_2O$ emissions (and greater nitrate leaching)**
- **$N_2O$ emissions are lower when soil temperature is below 15°C**
- **High soil carbon/organic matter mixed with soil nitrogen cause $N_2O$ emissions**
- **Ammonia based and slow release fertilisers reduce $N_2O$ emissions**
- **Take soil samples to see where your nitrogen is going**

On vegetable farms, organic matter is usually added as composts and amendments, or as cover crops or crop residues. High N organic amendments, such as lucerne mulch and compost, increase the risk of $N_2O$ losses.

## Soil testing can help you

Taking soil samples down to 30cm and having them analysed is an efficient way to manage soil nitrogen. Sampling before planting will tell you how much N is already available, which may be able to reduce required fertiliser inputs. Proper analysis will also show your limiting nutrients. Sampling after a crop will show your residual N. A deep-rooted cash or cover crop can recover some residual N.

## Sequester carbon in the soil, or mitigate nitrous oxide emissions?

Soil carbon content is a driver of nitrous oxide emissions so doing things that increase soil carbon can work against nitrous oxide abatement. Conversely, pursuing nitrous oxide abatement can work against soil carbon sequestration. The whole system must be considered to ensure that its total carbon footprint is lowered, not just one aspect of it.

The effect of soil management on nitrous oxide emission can clearly be seen here in Figure 3.

Farm 1 recorded higher soil organic matter, higher nitrate and used more fertiliser than Farm 2. Basal fertiliser was applied approximately 30 days prior to planting and the soil was saturated just after planting at both sites. As a result Farm 1 experienced a greater loss of N to the atmosphere.

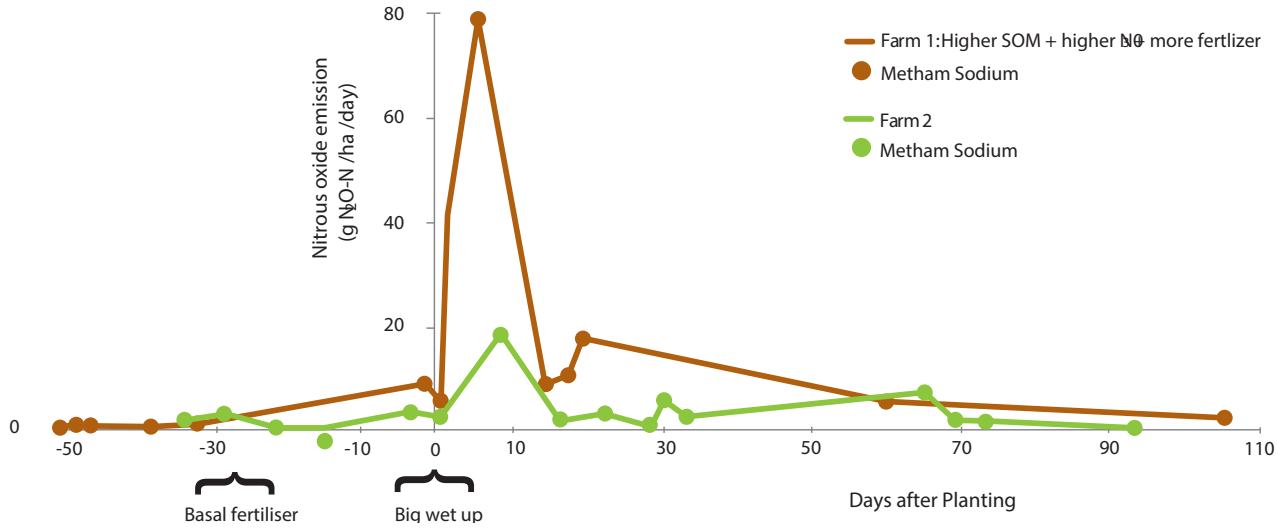



**Figure 3: Results of a study monitoring nitrous oxide emissions from tomatoes.** Source: K. Montagu, S. Moore, L. Southam-Rogers, N. Phi Hung, L. Mann and G. Rogers, Low nitrous oxide emissions from Australian processing tomato crops – a win for the environment, our health and farm productivity.