Mitigation of nitrous oxide emissions from horticultural crops and implications for the Montreal Protocol

Ian Porter[1], David Riches[1] and David Kanter[2]

[1] Department of Animal Plant and Soil Science, La Trobe University, Bundoora, Australia
[2] Department of Environmental Studies, New York University, New York, USA

E-mail: i.porter@latrobe.edu.au

Abstract

Over use of nitrogen and lack of regulation in many agricultural crop production regions globally is causing major environment damage and subsequent problems to human health.

Globally, benchmark studies have shown alarming levels of emissions of nitrous oxide from some high value horticultural systems where high inputs of inorganic and organic nitrogen are used. For instance in Australia growers in temperate climates apply up to 1 tonne of nitrogen per hectare to soil annually yet it is estimated that crops use only 40% and over 60% is lost to the environment. Technologies exist to reduce losses of nitrogen by 60%, however in spite of these being available there are no drivers to improve nitrogen use efficiency and avoid nitrogen pollution. Consequently, new policy options for limiting nitrogen pollution need to be explored, including amending the Montreal Protocol – the international ozone agreement – to regulate nitrous oxide.

Keywords: nitrous oxide, fertilisers, manures, Montreal Protocol, ozone depletion

1. Background

Nitrous oxide (N_2O) is the third most important greenhouse gas released into the atmosphere. Despite it also being the largest ozone depleting substance, it is not regulated under the Montreal Protocol, for the damage it causes to the ozone layer and subsequent negative effects of UV on human health and the environment (Kanter et al 2013).

Global models and emission inventories predict that approximately 5.3 Tg of anthropogenic N_2O-N is produced each year, with two-thirds of the emissions coming from direct and indirect fertilizer and manure emissions, which includes emissions from nitrogen (N) leaching and atmospheric re-deposition, (Davidson and Kanter, 2014). Overuse of nitrogen and its lack of regulation in many agricultural crop production regions globally is causing major environment damage and subsequent problems to human health.

Globally, benchmarking studies have shown alarming levels of emissions from high value horticultural systems where high inputs of N are used. However in spite of these findings in many regions there is little effort to improve N use efficiency (NUE) and avoid nitrogen pollution. And yet, a UN Environment Program report estimate that ambitious N_2O mitigation could avoid emissions equivalent to approx. 60 Gt CO_2 eq., and an improvement of 20% in NUE would save an estimated 23 million tonnes of N globally worth an estimated $US23 billion (UNEP 2013).

Regulations, such as EU Council Directive 91/676/EEC on nitrates and water quality has been partially effective in achieving controls on N use. Indeed, recent research studies have shown that a range of best management practices and technologies are now proving effective to reduce excesses of N use by ensuring that N supply more closely matches crop demand (Winiwarter et al. 2018).

2. Finding

In Australia, where vegetable producers in temperate regions apply up to 1 tonne of nitrogen (N) as inorganic fertilisers and manures per hectare per year to produce multiple crops on the same soil, annual N_2O emissions were up to 12.5 kg-N/ha (Porter et al, 2017). However the use of nitrification inhibitors on fertilizers and manures, and better application of manures were shown to reduce emissions of N_2O by up to 60% compared to the standard grower treatment (Fig 1) with no loss in yield. Similar high levels of N_2O emissions were found in managed turf from sports fields and the potential for better NUE and reduced N_2O emissions exists (Riches et al, 2019).

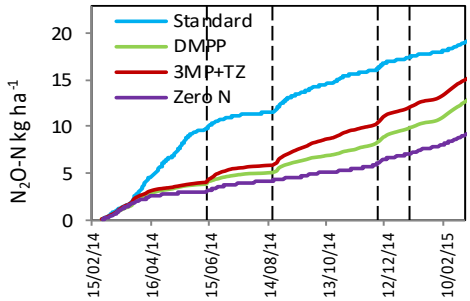

Fig. 1: Effect of nitrification inhibitors (DMPP and 3MP+TZ) on cumulative N_2O emissions for annual cropping of vegetables (3 crops and 2 fallows) in Victoria, Australia.

Despite the availability of mitigation technologies and practices, there has been little uptake by farmers – partly due to the lack of policy action on this issue. Adding N_2O to the Montreal Protocol would likely galvanize action in a way that previous efforts have not. The Montreal Protocol is ideally suited to take on N_2O for several reasons: it has universal participation, with every signatory legally required to address controlled substances; a successful financial mechanism aids developing countries in complying with their commitments; scientific assessment panels provide regular updates and respond to specific requests regarding recent scientific developments; and most importantly, the Montreal Protocol has a long history in dealing relatively successfully with the agricultural sector, given its regulation of methyl bromide. The most likely first step would be for the Montreal Protocol to create a special task force under its assessment panels to explore the technical and economic feasibility of controlling N_2O under its auspices.

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