Joe Muscat pictured during a Nuffield scholarship tour in Brazil.

Assessing nitrogen inside a plastic coat

The science of fertiliser use is at the frontline of an on-farm revolution that is improving productivity and stopping nutrients such as nitrogen from harming the environment.

Two years ago, central region farmer Joe Muscat, his wife Christine and son Stephen, yielded their biggest sugarcane harvest, with one of their north Queensland properties producing 126 tonnes of sugarcane (19.38 tonnes of sugar) per hectare. They averaged 105t/ha of cane across the total enterprise.

Mr Muscat, who farms 265ha of sugarcane at Oakenden, south-west of Mackay, says the record crop was due to a good growing season, which included the right amount of rain, sunshine and irrigation water, and changes to the way they manage soil nutrition.

Mr Muscat says the improved yield is the pay-off from changes they have made to the way they manage soil nutrition. "Soil health is the baseline for any farming system," he says.

These changes include the introduction of a legume crop during the fallow period between sugarcane crops, and testing new fertiliser regimes that improve the crop's use of nitrogen inputs so there is little of the nutrient left behind to run-off into waterways or escape into the atmosphere as nitrous oxide (N_2O).

Mr Muscat works with researchers to run on-farm experiments, one of which tested the effectiveness of a polymer-coated urea product called Agrocote® against sulfur-coated urea.

The objective was to find which fertiliser product achieved the highest nitrogen use efficiency (NUE) – the efficiency of the crop's use of nitrogen as an essential nutrient needed for crop growth.

With agronomy research company Farmacist, Mr Muscat found no significant difference in sugarcane or sugar yields between plots receiving the urea/sulfur blend at 184 kilograms of nitrogen (N)/ha and those receiving a urea/Agrocote® blend at 135kg N/ha in 2014 and 2015 – so there was no production penalty for using the polymer-coated product that delivered less nitrogen.

Although Mr Muscat found the cost of Agrocote® prohibitive, it did work, which is consistent with other research findings that show polymer-coated urea can increase NUE and sugar yield.

The objective, shared by all farmers, is to try and eliminate nitrogen fertiliser wastage. In these trials, the new polymer-coated urea achieved this, but more work will need to be done to make it more cost-effective.

Ingham experiments

Through the National Agricultural Nitrous Oxide Research Program (NANORP), principal scientist Dr Weijin Wang from the Queensland Department of Science, Information Technology and Innovation (DSITI) and colleagues from Sugar Research Australia and Herbert Cane Productivity Services undertook two experiments at Ingham from October 2012 to October 2014.

The work aimed to assess the effects of improved management practices on productivity, profitability, NUE and N_2O emissions using polymer-coated urea and urea coated with the nitrification inhibitor 3,4-dimethylpyrazole phosphate (DMPP), called ENTEC®.

Emissions from soil receiving different fertiliser formulations – conventional urea, polymer-coated urea and DMPP-coated urea applied to sugarcane at recommended and sub-optimal rates – were measured. Plant and soil samples were also taken to determine sugarcane productivity, sugar yield, plant nitrogen uptake and the soil's mineral nitrogen content.

Dr Wang says the research suggests use of both polymer and DMPP-coated fertiliser products could potentially reduce application rates, increase NUE and reduce greenhouse gas emissions.

For example, in the 2013-14 experiment at Ingham he found that using ENTEC® increased sugar yield by about 30 percent (2.8t/ha) and gross margins by about 23 percent compared with conventional urea applied at the recommended rate of 150kg N/ha. It also decreased annual N_2O emissions by about 50 percent.

Dr Wang says that using ENTEC® increases the cost of fertiliser by about $60/ha compared with conventional urea at an application rate of 150kg N/ha. "However, reducing the nitrogen application rate by 25 percent did not negatively affect the sugar yield, which can largely offset this higher fertiliser cost," he says.

Although the polymer-coated urea increased N_2O emissions compared with conventional urea, decreasing the fertiliser application rate from 150kg N/ha to 110kg N/ha reduced the total N_2O emissions by about 50 percent with no sugar yield loss.

The experiments also highlighted the affect that different soil and weather conditions, in particular wet weather, can have on nitrogen fertiliser loss due to denitrification. This is the process in which soil microbes convert nitrate to nitrogen gases including N_2O.

Waterlogged soils are particularly prone to N_2O emissions as a consequence of denitrification. N_2O is also an indicator of much larger emissions of dinitrogen (N_2), which can exceed N_2O emissions by as much as 50:1 – a significant economic loss.

NANORP research has found that denitrification is the principal source of N_2O emissions from most agricultural soils in Australia. It is widespread in wetter areas – such as some tropical and subtropical sugarcane-growing areas.

In the first experiment at Ingham, very high N_2O emissions (11.3 to 18.1kg N/ha/year) were recorded.

"These emissions were driven predominantly by rainfall rather than nitrogen fertiliser application," Dr Wang says. "There were no significant differences between different urea formulations and application rates."

For Mr Muscat, whose family has been farming at Oakenden for 50 years, an incentive for using polymer-coated urea is to reduce nitrogen leaching on paddocks prone to waterlogging. "It makes no sense to be putting nitrogen down and then losing it," he says.

Although his on-farm trials with Agrocote® showed it worked, and reduced their nitrogen fertiliser use by about a quarter without any yield decline, they also found it was too expensive. "It is about $800 to $1000/t more expensive than urea." In 2016, he is continuing to try more nitrogen-efficient fertilisers including ENTEC®.

Mr Muscat also uses legumes to improve NUE and soil health, and has recently started planting the Brazillian fibre crop sunn hemp.

He says sunn hemp has the ability to add 300kg N/ha to their sugarcane yield and produce 22t/ha of dry matter. "The downside is propagating planting seed and it is an intensive seed crop to produce, requiring a heavy spray program – issues we are working to address so we can plant more in coming years."

More information

Joe Muscat
0429 377 162
josephm@jcsenterprises.com.au

Dr Weijin Wang
Queensland DSITI
07 3170 5768
weijin.wang@dsiti.qld.gov.au

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