Exhaust technology at the cutting edge

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Innovative technology claimed to save American farmers $100 a hectare in fertiliser costs is being used in Australia.

Bio-Agtive Emissions (BAE) technology, which injects vehicle exhaust emissions into the soil via the seeder during seeding, is at the cutting edge of agricultural technology, according to Brad Modra, who heads the Australian arm of N/C Quest (NCQ), which is marketing the technology world-wide.

Exhaust injection is claimed to stimulate microbial activity in the soil, resulting in mineralisation of nutrients from the soil and production of nitrogen (N) by free-living N-fixing bacteria. This is said to improve root and plant growth, leading to better crop performance and changes in the harvest ratio of crops, making them more drought tolerant.

Other claims for the exhaust injection technology, developed by Canadian farmer Gary Lewis, include improvements in:

- soil condition and structure, which increases water-holding capacity
- crops' ability to avoid or withstand insect attack
- performance of crops sown in saline soil conditions due to increased availability of calcium and phosphorus, which makes the plants better able to withstand the saline soil conditions.

Mr Lewis, principal of N/C Quest Inc., says injecting exhaust gases helps restore the carbon:nitrogen balance in the soil, with the exhaust gases contributing nutrient compounds and stimulating nutrient release from the soil while also sequestering carbon. How this might occur is one of the key questions posed by this technology.

The Australian experience is that there is an immediate benefit in the first year.

Hard scientific data on the impacts of the BAE technology are difficult to find, with most of the supporting material observation-based anecdote, often about improved root growth and soil condition.

A large-scale trial in the low-rainfall Mallee region of south-western NSW in 2009 reinforced the impact of soil variability and moisture availability on crop performance without providing any insight to whether or not the technology might be of value in low-rainfall conditions in Australia.

The report detailing the results of that trial, carried out under the auspices of the Lower Murray Darling Catchment Management Authority, says 'there is no existing scientific literature on the effectiveness of this technology'. Such supporting material continues to be difficult to locate.

The lack of data from formal independent research into this technology can be attributed in part to the fact that it was developed in 2001 and was first used in dryland cropping only five years ago.

However, formal research into aspects of the technology is underway. This work includes chemical analysis of the condensate from diesel and other fuels, which has shown that it contains minute amounts of a variety of mineral nutrients including copper and zinc, and research into its effects on seed and biological interactions in the soil being undertaken by soil biologist Dr Jill Clapperton, who was a keynote speaker at the 2007 SANTFA annual conference.

Dr Clapperton, in a recorded segment on the Bio-Agtive web site, says she has no doubt there is 'something going on' when crops are sown with exhaust emissions from the seeding tractor.

She has found that germination rates of seed sown with exhaust emissions are greater than those of seed sown without emissions – an effect that varies with crop type – and that there is less fungi on 'treated' seed; which suggests the exhaust gases affect the microbiology of the seed coat and possibly seed-borne fungi, she said.

According to Dr Brett Whelan, Senior Lecturer in Precision Agriculture at the University of Sydney, specific questions that need to be explored in relation to this technology include:

- Does injecting diesel exhaust increase CO^2 concentration in the soil and

A BOURGAULT AIR-SEEDER FITTED WITH BIO-AGTIVE EMISSIONS TECHNOLOGY THAT INJECTS TRACTOR ENGINE EMISSIONS INTO THE SOIL.

BIO-AGTIVE EMISSIONS (BAE) TECHNOLOGY IS USUALLY USED IN CONJUNCTION WITH SEEDING BUT BAE SYSTEMS CAN ALSO BE FITTED TO OTHER EQUIPMENT SUCH AS PLOUGHS OR CULTIVATORS.

stimulate biological activity, and if so, how much would it contribute to nitrogen availability in the soil?

- The impact in the soil of the carbon contained in the exhaust emissions.
- Whether or not injecting exhaust does increase soil carbon levels.
- Whether or not micro nutrients in the fuel are oxidised in the diesel engine and injected with the exhaust gas.
- If the technology is shown to have an effect, how it best be used to maximise the sustainability of cropping systems.

There are currently about 35 Bio-Agtive units on farms Australia-wide and Brad Modra expects that number to almost double in the next 12 months.

About eight of those units are on properties in central NSW, where growers have been hard hit over successive years by poor prices, drought and more recently summer rainfall that has damaged crops.

Many growers in this region are under extreme financial stress and have to find some way of reducing costs if they are to continue farming, he said. This technology offers a way to achieve that and improve crop performance.

There are reports of growers who had installed the technology, which costs in the order of $40,000 per machine to install plus licence fees in excess of $15,000, but are now no longer using it, something Brad attributes to concerns about the potential to run down nutrient reserves if the exhaust technology replaces fertiliser application.

However, there is no indication of nutrient depletion from either crop performance or 'before and after' soil test results, he said, and in central NSW conditions, soil phosphorus levels in paddocks where exhaust injection is used are often higher after harvest than they were at seeding.

Nutrient rundown has not been raised as a concern in relation to use of the biological 'phosphorus solubilising' product developed and commercialised with the support of the GRDC.

Diesel exhaust composition varies with engine design, the fuel being used and the load under which the engine is working, but in broad terms a diesel engine emits 79% nitrogen compounds, 11% oxygen, 7% CO^2, 3% water and minute amounts of trace elements and hydrocarbons, plus particles comprising a core of carbon with organic and other compounds on their surface.

Brad has no doubt about the benefits and effectiveness of injecting this complex mixture into cropping soils, notwithstanding the lack of hard scientific data, because he is seeing the results in growers' paddocks.

And he is confident much of the benefits from this process result from stimulation of soil organisms; which makes it difficult to generate 'hard' data about how the technology works.

Interactions between populations of soil organisms and between soil organisms and plant roots are notoriously complex and the effects of those interactions equally difficult to identify and measure.

"Diesel exhaust emissions contain only small amounts of nutrient so injecting them into the soil has little direct

nutritional benefit. The effect comes from stimulation of soil organisms and their interactions with the crop roots.

"There has never been an instance, in Australia, the US or anywhere else the technology is being used, of it damaging crops or reducing crop performance," he said.

"The Australian experience is that there is an immediate benefit in the first year with no drop in crop performance, and because the gases stimulate the soil biology, those benefits compound with on-going use."

According to a draft version of the licence used by N/C Quest in Australia, growers entering into an agreement to use the technology acknowledge that it is 'experimental and utilises new and revolutionary technology'.

This point is emphasised by the fact that the BAE technology was first used in the field in 2005 and that the equipment used to cool the exhaust gases and carry them from the tractor to the seed box is being continuously refined in response to grower experience and feedback.

Current versions of the equipment, which carry exhaust gases through a condenser to the air-seeder fan, are much 'cleaner' and more streamlined than earlier versions.

The only moving part in the computer-managed BAE equipment is a fan, driven from the tractor hydraulics, that draws the emissions away from the engine, so there is no back-pressure issue, and into a condenser.

TOP: IN SEEDER SYSTEMS THE EXHAUST EMISSIONS ARE PIPED FROM THE TRACTOR EXHAUST PIPE THROUGH A CONDENSER AND INTO THE SEED DISTRIBUTION SYSTEM. BELOW: A WORM'S-EYE VIEW OF A BIO-AGTIVE EMISSIONS SYSTEM ON AN AGRISEM TOOL BAR FITTED WITH DEEP RIPPING TINES.

CARBON POTENTIAL TOO

Gary Lewis says his exhaust technology opens the way to sequester carbon in soils being used for food production.

According to N/C Quest (NCQ), the Bio-Agtive emissions technology - referred to both as NCQ and BAE technology - is an 'additional practice' as defined in the National Carbon Offset Standard (NCOS), which would open the way for any measurable carbon increase to be traded in a 'carbon market'.

The company claims to have identified emission monitors capable of recording data 'for the possibility of carbon trading' and has created a companion entity, CO2Xchange, which is described as a carbon verification program that will offer farmland where the technology is used for 'sponsorship' by consumers.

When consumers sponsor a farmer to improve farming practices, increased sequestration of carbon naturally follows, the company says.

NCQ requires 'first and last refusal' on carbon credits generated by a grower from use of the technology as a condition of the licence growers are required to sign to gain access to the technology.

Greg Butler, SANTFA R&D Manager and a member of the Federal government's Soil Carbon Technical Working Group, suggests cereal farmers in southern Australia be very cautious about granting third parties trading rights to carbon accumulated in their soils.

"SANTFA members are encouraged to discuss any carbon-related issues with me before signing on to a carbon-trading scheme."

The condenser uses passive air-to-air cooling achieved by cool ambient air passing over pipes carrying the hot exhaust gases. The temperature of the exhaust gases reaching the seed box is controlled by adjusting the fan speed to maintain the level of heat exchange needed to achieve the target temperature, which is maintained at a level that is cool enough not to damage the seed but not cold enough to condense the moisture in the exhaust gases. On cold days the fan may not run at all. In hot conditions it will operate at neat maximum capacity.

Every kilogram of diesel fuel used produces two litres of water, Brad said, so avoiding moisture from the exhaust condensing inside the seed box has been one of the key technical challenges for the engineers working on development and refinement of the system.

The moisture content of the condensed exhaust gases means it is impractical to apply fertilisers or other granular or powdered products, including seed pickles or fungicides, through the seed box when using BAE technology.

However, this is not considered a major risk or impediment because of the stimulatory effects of the emissions in the soil and the 'seed treatment' effect identified by Dr Clapperton, which together minimise the risk of root disease problems in crops sown with exhaust gases, Brad said.

The effect of the emissions on the soil biology, and the fact that stronger plants with larger root systems were better equipped to stimulate soil organisms to provide the nutrients they required, mean nutrition is not usually an issue either. However, growers wanting to apply nutrients and inject their exhaust emissions into the soil could broadcast fertiliser ahead of seeding, use a liquid fertiliser at seeding, or apply nutrients during the growing season as a foliar spray, by broadcasting a solid product or 'streaming' a liquid product into the crop, he said.

But applying fertiliser can reduce the benefits achievable from exhaust injection because providing significant amounts of available nutrients can have the effect of 'shutting down' the soil biology by removing the need for the soil organisms to 'work' to release nutrients from the soil bank.

BIO-AGTIVE SYSTEMS ARE CUSTOM-FITTED TO THE TRACTOR AND TILLAGE EQUIPMENT.