FULL INVERSION PASTURE RENEWAL COULD SLOW CLIMATE CHANGE

THE NEW ZEALAND GOVERNMENT HAS SET SOME AMBITIOUS TARGETS TO REDUCE GREENHOUSE GAS EMISSIONS. THESE WILL CONTRIBUTE TO THE EFFORT TO LIMIT THE GLOBAL AVERAGE TEMPERATURE INCREASE TO 1.5°C.

The agricultural sector produces about 49 percent of New Zealand's total greenhouse gas emissions and most of these emissions are associated with pastoral agriculture. Removing more CO_2 from the atmosphere and storing more carbon in soils is a promising option to reduce the nation's net emissions.

Dr Mike Beare and a team of scientists from Plant & Food Research, Massey University and Manaaki Whenua are investigating how pasture renewal practices can be improved to store more carbon in soils.*

The focus of the team's research is on the potential to increase soil carbon storage following pasture renewal using full inversion tillage.

Mike says the top 150 mm of many pasture soils are approaching carbon saturation. However, below 150 mm there is the potential to store a lot more carbon. This is because most pasture roots are concentrated in the top 150 mm and roots are the main source of the carbon stored in soil. (See sidebar on soil carbon saturation.)

The premise is that full inversion tillage buries carbon-rich topsoil and brings the low carbon subsoil to the surface where it can store more carbon from actively growing plant roots. In many soils, the ideal depth of full inversion tillage is about 30 cm

Over time, this creates deeper topsoil that is rich in carbon to a lower level and also potentially more productive. It removes more carbon from the atmosphere, which will help off-set the greenhouse gas emissions from other forms of human activity, including agriculture.

"The organic matter that we have buried will slowly break down but the soil should retain more stable carbon than was in the original subsoil. It also creates the capacity to store more carbon in the new surface soil." The vigorous growth of new pasture is important to build this carbon in the new surface soil.

Pasture renewal is the ideal time to use full inversion tillage. Renewal typically involves a fallow period, when the old pasture is sprayed-off and the new pasture is established after shallow tillage or by direct drilling.

Along with carbon, inversion tillage also buries weeds, minimising the need for spraying off the old pasture. By avoiding a lengthy spray-off period, full inversion tillage can have a much shorter fallow period.

"In many cases the new pasture can be sown within a few days of spraying and ploughing the old pasture," Mike says.

"This means the paddock is in production longer, which also minimises the risk of nitrogen losses when there is no active plant growth."

Another issue to consider is the frequency of full inversion tillage. Regular use of tillage can lead to loss of soil carbon, particularly in continuous cropping systems where the carbon returned to soil from roots is lower.

This loss of carbon can lead to a decline in soil fertility and the breakdown of soil structure, which is important for soil water storage and aeration. However, a one-off or very infrequent use of full inversion tillage for pasture renewal would minimise these risks and allow time for the new pasture to build carbon in the new topsoil.

Mike says there needs to be more research on how often it should be done, but the team's best estimates indicate not less than every 30-50 years. That is the theory, but in practice we need to verify that pasture renewal with full inversion tillage will store more carbon over time, and that it can be done with minimal cost and without a loss of production or environmental damage.

THE PASTURE RENEWAL TRIAL AT LINCOLN.

MOULDBOARD PLOUGH WITH DISC COULTER AND SKIMMER TO BURY TOPSOIL.

SOIL CARBON SATURATION

Mike Beare says there is a debate in soil science about how much carbon soil can store.

"There is some evidence that soils can only stabilise a maximum amount of carbon, because carbon bonds to mineral surfaces and there is only so much surface to bond to."

But soils differ in their mineral surface area and, therefore, their capacity to stabilise carbon.

Once the soil is saturated with carbon, any further carbon added by plant roots is much less stable and more easily lost through decomposition.

"We have developed techniques to predict the capacity of individual soils to store carbon based largely on surface area. They seem to work reasonably well, but there are still aspects we don't understand," Mike says.

Plants with deeper roots are ultimately not a solution to the problem. Mike says there are not enough plants that produce large enough root systems to deposit high amounts of carbon at that level.

When deeper roots die, they enter the decomposition cycle and microbes rapidly break them down and the rest is respired to the atmosphere. There just is not enough carbon coming down to the lower levels from plants. **RC**

The project team presented six papers on their research at the Farmed Landscapes Research Centre workshop held at Massey University in February.

The papers focussed on the first several years of trials that looked at production after inversion tillage, measured environmental losses and considered the timing of pasture renewal, i.e., spring or autumn? Overall, the best results were obtained with full inversion tillage in spring, particularly where a crop is sown as a break between old pasture and new pasture.

Applying full inversion tillage in the autumn increased the risk of nitrogen leaching over winter in a typical grass-to-grass renewal practice. Growing a supplementary feed crop as a transition between old and new pasture markedly reduced this risk of nitrogen leaching, however.

Break crops like forage oats are winter active and have deep root systems that mop up a lot of extra nitrogen. These break crops also produce a lot more dry matter over the winter period than pasture.

It appears that the benefits of full inversion tillage are even greater in spring.

The rapid growth of new pasture or crops after full inversion tillage in spring seems to actually reduce the risk of nitrogen leaching compared to renewal by shallow tillage or direct drilling. And the production of spring-sown crops and pasture is often higher following full inversion tillage compared to traditional renewal practices.

In many cases, the extra cost of full inversion tillage renewal is easily off-set by the value of the extra feed produced over the first year following renewal.

Higher production is probably linked to greater nitrogen availability. Another possible explanation is that full inversion tillage helps to reverse the compaction formed by continuous stock treading. This could improve the storage of water in the soil and allow roots to penetrate deeper to access nutrients and deposit carbon.

This appears to be a happy win-win for farmers – reduced environmental losses and better forage production. However, Mike points out that "we need more trials before we can assume it applies equally well across a wide range of soils and climates. And of course we need to demonstrate that pasture renewal following full inversion tillage leads to increased carbon storage, which will require longer-term trials.

"There is evidence from modelling work and earlier trials which show that we can build carbon in those soils over time. It looks promising that we can sequester carbon and mitigate the risk of environmental losses."

This is of interest not just to dairy farmers, but all pastoral farmers with topsoils that are deep enough for ploughing with relatively few stones, and where the slope is less than 15 degrees.

The ideal soils are those under continuous pasture where carbon content in the topsoil (0-15 cm) is at least 1.5 times that of the subsoil (15-30 cm). A strong difference suggests that if inverted there is the potential to store more carbon.

A happy accident is that full inversion tillage can also reduce nitrous oxide emissions.

"Nitrous oxide emissions from fertiliser and livestock urine are an important source of greenhouse gas emissions from agriculture.

"Our preliminary results suggest that full inversion can reduce these emissions compared to renewal by direct drilling.

"Minimising the fallow period between old and new pasture may also help to reduce the nitrous oxide emission during pasture re-establishment. This is an area that the research team want to investigate further."

In the short term, Mike and the project team are writing up guidelines for farmers and consultants on how, where and when full inversion can best be used to sequester carbon from pasture renewal while avoiding adverse environmental impacts.

How much carbon could we store with pasture renewal following full inversion tillage? The team has completed a separate study to model the effects of full inversion tillage using existing soil carbon data from across New Zealand.

The results indicate that about 32 million tonnes of carbon could be stored over 20 years across the 2 million hectares of land that is suitable for full inversion pasture renewal. If this was done, the yearly increase in carbon would equal about 15 percent of New Zealand's annual agricultural greenhouse gas emissions.

This is a big number but it assumes 100 percent adoption. However, even a 20-30 percent adoption rate could make an important contribution to reducing New Zealand's agriculture greenhouse gas emissions.

*The team's research is funded by the Ministry for Primary Industries to support the objectives of the Global Research Alliance of Agricultural Greenhouse Gases. **RC**