N. BRUCE ULLRICH O.B.E *Company Director*

B.Com (Cant), M.B.A (Massey), F.Inst.D (UK), CA ANZ (Hon.), FIANZ, Hon. Professor (Shanxi University TCM & Beijing Open University)

P.O. Box 212, Christchurch 8140, New Zealand Email: manager@investnz.co.nz Website: www.investnz.co.nz Telephone ++64 3 357 8242

25th October 2021

The External Reporting Board

Institute of Directors

PO Box 11250

Manners Street Central

WELLINGTON

TO WHOM IT MAY CONCERN

I have been a member of the Institute of Directors (UK) since March 1973 when I was awarded a Fellowship by the UK Institute based on my then involvement on Boards, as the then Chair of the University of Canterbury Finance & Property Committee and a member of the UC Council (1970-91), Vice Chairman of the Organizing Committee of the Xth British Commonwealth Games (1970 -74) and I had just retired at the age or 35 after 12 years as a partner of one of the founder firms of ***KPMG*** and had just collected a Directorship representing an Australian public company, of NZ's second largest White Goods manufacturers. My focus from that time was business advisory rather than accountancy and it gave me more flexibility to also pursue my interests in sport and education matters which latterly took up a huge chunk of my time. In around 1975 for 10 years I also took on the task on a "pro bono" basis, as Secretary of the Canterbury branch of the I of D and we had a small Committee of 'local celebrities' who had joined the I of D., overseeing with me our branch activities.

I have had an involvement with a world class New Zealand invention since 1995 called "Cross-Slot" - refer www.CrossSlot.com initially as an adviser, but then as a Director. Dr John Baker the inventor of the drill at that stage had left Massey University and with several fellow staff members set out to strike on their own. Since that date 160 drills have been sold and are operating in around 20 countries in various parts of the world. It was a technology before its time when climate change was not a buzz word, but John Baker canvassed what soil scientists required in a seed drill which did not create the 20% odd of carbon emissions caused by arable farmers world wide – in fact the "Cross Slot" drills created carbon credits for the "Carbon Capture" market and improved the quality of the soil which is now loosely referred to as "conservation tillage". Unfortunately the NZ Climate Change

Commission seems to ignore this vital part of NZ's carbon emissions and focuses more on body 'emissions' from animals. – a very minor percentage.

Of the world's food, 85% comes from arable crops and only 4% of the world's soil is arable land. What is disturbing is the way this arable soil is now losing out to property development for the growing populations of the world. Therefore, the world must be smarter on the way it grows crops and this diminishing arable land will need more efficient ways of producing food for the world.

Instead of manufacturing the drills in New Zealand which has been difficult because of high costs of production and slow progress of the sale of drills, about 3 years ago the Company restructured to licence the technology (the opener or the blade that sows the seed is largely the I/P) in various countries and to have a series of global manufacturers in place to assemble drills to the Cross Slot specification under NZ direction.

During all this time Dr Baker had won many awards and accolades for his invention and over the years he had also collaborated with other international universities . The Queen awarded him with an ONZM for services to agriculture; he has won a number of accolades from his peers; he was twice nominated for The World Food Prize and the FAO (the UN) commissioned him to write a book about the technology.

I resigned from the UC Council in 1991 after being Chef de Mission of most of NZ's Olympic & Commonwealth Games in the 1980s (two with a record haul of medals) to enrol for a MBA at Massey University in 1990 – from 1995-98 I found myself as National President of the Massey MBA Alumni (by far the largest MBA Network in NZ) and in 2006 I was elected to the Massey University Council as the sole male Alumni representative, a position I held until I retired from their Council at the end of 2015. This also gave me the opportunity of focussing my interest on agriculture and its commercialization internationally. Since 1998 I had also made around 40 visits to China mainly with regard to developing agricultural links, marketing education and establishing clinics, initially for the treatment of diabetes.

I attach three papers which will be of interest:-

1. *"An idea whose time has come"* – edited by my wife who passed away during the year.
2. An information Memorandum re the influence of Cross Slot low disturbance on soil organic carbon and organic nitrogen levels on arable farms in NZ – if the I of D wished to take this matter further, Dr John Baker would be only too pleased to speak with your group. At the age of 81 he still works full time and is based in Feilding.
3. An article based on recent research "How no-tillage can mitigate climate change".

Yours sincerely

N B Ullrich

"An Idea whose Time Has Come"

The Impact of Cross Slot® Low-Disturbance No-Tillage on Climate Change

Dr C John Baker, ONZM, PhD, MAgrSc (Hons), FIAgrE, CE,

(Edited by Jeannette Ullrich)

The Purpose of this Submission:

- ✓ To point out that Government's heavily-weighted focus on reducing emissions in order to lower levels of atmospheric carbon, appears to be simultaneously ignoring New Zealand's existing technological leadership in methodologies for returning existing atmospheric carbon to the soil.
- ✓ To highlight the fact that New Zealand already leads the world in designing technologies to facilitate terrestrial carbon recycling and sequestration.
- ✓ To remind policy makers that the New Zealand's carbon sequestration methodology is a bi-product of equally important food production technology that has been spawned by a need to produce more food from the dwindling area of the earth's surface that is arable land but is nonetheless expected to produce most of mankind's food.
- ✓ Not only are NZ politicians missing a leadership role, society is ignoring unimaginable export and job creation opportunities.

This submission is designed to awaken policymakers.

Overview:

- ❖ The world's arable soils occupy only 4% of the earth's surface but provide 85% of mankind's food.
- ❖ Most arable soils have become almost biologically inert with very low levels of soil organic matter as a result of oxidation of labile soil carbon from hundreds of years of conventional tillage by the world's farmers.
    - This is a prime cause of dwindling crop yields, desert formation, dust storms and famine.
    - This deterioration is exacerbated by Climate Change.
    - Climate Change is exacerbated by net emissions of carbon from all sources.
- ❖ With application of New Zealand's Cross Slot® low-disturbance no-tillage (LDNT) system and equipment for sowing and growing arable crops, a new basis for simultaneously regenerating soil health, increasing crop yields and mitigating climate change is being applied with measurably positive results.

- This takes effect on several fronts:

    - Removing excessive CO_2 from the atmosphere helps mitigate climate change.
    - Transferring the C removed from the atmosphere into the soil feeds the soil biology.
    - Nitrogen leaching from NZ soils is reduced.
    - Soil sedimentation of NZ waterways is reduced.
    - Chemical pollution of streams carried in run-off water is reduced.
    - Crop and pasture yields are increased.
    - On-farm costs are reduced.
    - Farm profitability is increased.
    - New NZ jobs are created in designing and manufacturing specialist equipment .

- With NZ farmers currently sowing approximately one million hectares of new seeds annually, there is significant potential for soil-health regeneration and mitigation of all negative issues.

- Introduction of a Cross Slot standard to regenerate soil health internationally, has both global and domestic significance because:

    - The tool and method was invented, and is still owned by New Zealanders.
    - NZ's "clean and green" image would be firmly re-emphasised by demonstrating how soil health can be regenerated by mimicking and assisting nature's own processes.
    - A key factor determining the export potential of this technology to other countries is determining each country's ratio of arable land to total GHG emissions. The higher the ratio, the greater the potential impact of low-disturbance no-tillage.
    - Our near-neighbour and largest trading partner, Australia has the highest ratio of arable land to GHG emissions in the world. NZ's ratio is about mid-scale.

Limitation of this Submission:

- The points outlined in this submission are deliberately brief without detail. Each point, however, is backed by referenced science and/or supported by international authorities.

What is low disturbance no-tillage?

a) Low-disturbance no-tillage is a unique (and relatively recent) process that sows agricultural food-and-pasture-crop seeds into uncultivated soils while restricting the disturbance of the soil and surface vegetation to the absolute minimum. When sowing seeds into (and through) heavy surface vegetation, a defining characteristic is that it is often difficult to see where a low-disturbance no-tillage machine has been.

b) The general practice of conservation-tillage was invented in New Zealand in the 1950s *[Robinson and Cross, 1957]*.

c) Refinement of conservation tillage into the more exacting and specialised practice of low disturbance no-tillage also took place in New Zealand *[Baker et al, 1979; 2012; 2015]*.

d) There are currently only a small number of machines in the world that are capable of performing true low-disturbance no-tillage.

e) Low disturbance no-tillage machines create less soil disturbance than any other form of conventional tillage, conservation tillage or strip tillage. In doing so, they create opportunities to recycle carbon-and-nitrogen-rich crop residues and cover crops into the soil

at the same time as they sow new seeds and fertilizer. In this way, they rebuild soil organic matter levels during the crop establishment process *[Leabourn, 2017]*.

f) By contrast, conventional seeding processes remove carbon cumulatively from soils as invisible (but climatically-damaging) carbon dioxide when establishing new crops or pastures *[Leabourn, 2017: Baker unpublished data, 2017]*.

What is unique about New Zealand's Cross Slot® low-disturbance no-tillage?

i. Cross Slot low-disturbance no-tillage evolved from 30 years of publicly-funded research and development at Massey University *[Baker et al, 1996, 2006; 2012; 2015]*.

ii. Unlike competing brands of low-disturbance no-tillage machines that have followed, extensive published and peer-reviewed international science has defined almost every function that Cross Slot low-disturbance no-tillage machines perform before any engineering design took place *[Baker et al, 1996; 2006]*.

iii. This NZ science (which involved 27 graduate students and several staff) has never been challenged anywhere in the world.

iv. The Cross Slot science and engineering designs have been recognised by FAO; the US Senate; the World Technology Forum (New York); the Royal Society of NZ; the Queen; the Clarke-led Labour Government; the NZ Fieldays Society; the Henty (NSW) Field Days Society; and the World Food Prize panel (Iowa).

v. An international text book summarising the science was commissioned by FAO in 2006 and has become a standard university text *[Baker et al, 2006]* in several languages.

vi. Most competing brands of low-disturbance no-tillage machines are imported and few meet the exacting criteria that define low disturbance no0tiilage.

vii. Published science on the biological functions of competing brands of low-disturbance no-tillage machines has been largely negative *[Baker et al, 1996; 2006]*.

viii. As a result, Cross Slot low-disturbance no-tillage is the only cropping technique proven independently to regularly increases crop yields *[Saxton and Baker, 1990; Grabski et al, 1995; Hamilton-Manns, 2004; Poole, 2007, 2011]*.

ix. This ensures that it is more cost-effective in practice than all other conventional or conservation seeding processes (imported or otherwise).

In what manner does Cross Slot low disturbance no-tillage benefit (a) climate change, (b) the environment, (c) soil health, (d) world food supply, and (e) the NZ economy?

(a) Climate change:

- Cross Slot low-disturbance no-tillage with full residue retention is the only seeding process in the world proven by science to be consistently carbon-positive *[Ghatohra, 2012; Leabourn, 2017]*. In NZ, the process has been shown to be capable of sequestering net about 500 kg/ha of new carbon into the soil annually. By comparison, conventional tillage is consistently carbon negative and emits net about 2.0 t/ha of carbon into the atmosphere annually *[Baker, unpublished data, 2017]*.
- The difference of 2.5t/ha of carbon equates to a reduction of 9.2t/ha of net CO_2-equivalent emissions *[1 kg of elemental carbon is equivalent to 3.67 kg of CO_2]*.

- If all of the 1 million hectares of NZ farmland that is seeded each year *[NZ Agricultural Statistics, 2015]* is undertaken using Cross Slot low-disturbance no-tillage, about 11% (or 9.2 million tonnes) of NZ's total of 80.2 million tonnes of annual CO_2-equivalent GHG emissions from all sources *[NZ Ministry for the Environment on-line data, 2017]* would be mitigated by this seeding process alone each year.
- A key factor is that the technology for doing this, already exists in NZ and 20 other countries.
- The environmental performance of competing brands of low-disturbance no-tillage machines are unknown because none (other than Cross Slot) have so far been scientifically evaluated in this regard.
- Since 48% of NZ's total emissions are believed to come from agriculture *[NZ Ministry for the Environment on-line data, 2017)* the single act of changing all agricultural seed sowing practices in NZ to Cross Slot low-disturbance no-tillage, would mitigate about 24% of NZ's total agricultural GHG emissions.
- Following its introduction in 1998, it is estimated that about 7% of all seeding in NZ is already undertaken by Cross Slot low-disturbance no-tillage *[Baker unpublished data 2016]* plus probably a smaller amount by other brands of low-disturbance no-tillage machines.
- The challenge for Government is how to incentivise more NZ farmers to change to low-disturbance no-tillage seeding?

(b) The environment:

- All low-disturbance no-tillage techniques reduce the fuel used by tractors during seeding by about 80% and greatly reduce soil erosion that is otherwise caused when tilled soil is scoured into streams by heavy rainfall or wind events.
- For the same reason, the process greatly reduces fertilizer and pesticide run-off into waterways.
- As well as organic carbon recycling, it also has the potential to recycle organic nitrogen that is not readily leached, thereby reducing the need for the application of inorganic forms of nitrogen that leach more readily into the ground water.

(c) Soil health:

- When the residues of harvested crops or cover crops (including pastures) are left to decompose on the surface of the ground (which is a fundamental and unique function that helps to define low-disturbance no-tillage) the carbon- and nitrogen-rich products of this decomposition are taken into the soil by earthworms and other soil fauna and become the foodstuff of essential soil microbes.
- By contrast, conventional tillage practices involve burning, burying or baling crop residues to avoid blocking machinery and this prevents nature's carbon- and nitrogen-recycling processes from taking place *[Reicosky, and Saxton, 2006]*.
- When greater soil disturbance occurs, the soil is cumulatively stripped of organic matter and water, and with them, soil life.
- While forestry is also capable of removing similar amounts of CO_2 from the atmosphere, as agricultural crops for any given land area *[J P Praat, personal communication, 2017]* forestry and arable cropping target different classes of land, making them complementary rather than competitive. Nonetheless, arable food crops have the advantages that they (a) also feed us, and (b) offer their photosynthesised carbon products for sequestration into the soil, annually rather than every 20-30 years.

- Improved soil health almost guarantees improved crop yields and almost unlimited sustainability of land-use for continuous arable cropping *[Reicosky and Saxton, 2006; Ross et al, 2000]*.
- Cross Slot low-disturbance no-tillage has the ability to not only recycle surface residues in the manner that nature intended, but also to uniquely utilise these mulches to control the newly-sown seed's soil micro-environment, which virtually guarantees germination and significantly reduces the need for irrigation in dry climates *[Baker et al, 1996, 2006]*.

(d) World food supply:

- NZ's relatively small size ensures that it will only ever contribute a minor proportion of the world's total food supply.
- Only 4% of the world's surface is arable soils *[Wikipedia on line, 2017]* and this produces 85% of its food *[Borlaug, 1994]*.
- The unique Cross Slot low-disturbance no-tillage technology is the most effective and environmentally-friendly seed-sowing tool ever devised. Unlike the plough that it replaces, it has a unique ability to simultaneously (a) regenerate and sustain soil health, (b) increase crop yields, and (c) mitigate climate change.
- It is an important tool that will assist the world's farmers achieve the 50% increase in food volume that most experts believe will be required by 2050.
- There is an almost unlimited international market potential for this NZ-designed tool that is so large that it requires the support of a Government that is prepared to intervene where necessary as well as help to stimulate domestic demand through subsidized investment in new environmentally-positive machinery (as does the EU) and/or inclusion in the expanded domestic Emissions Trading Scheme.
- Cross Slot could be the largest manufactured engineering product ever exported from NZ if business and government pull together.

(e) The NZ economy:

- Every issue described above has the potential to have a positive effect on the NZ economy and employment.

ENDORSEMENT:

I first met Dr John Baker about 20 years ago when I was introduced to his Cross Slot drill, having been advised that it had been designed to meet the qualities recommended by soil scientists to change the way farmers could save the soil and prevent carbon emissions. Even then I recognised that the Cross Slot drill had the potential to be NZ's greatest invention, a viewpoint strengthened by the challenges now being faced and more widely recognised. I was pleased to accept an invitation to become an independent Director of their company, a position I remain in today.

After 20 years of modification and improvement, and now operating in more than 20 countries, there is the increasing need for farmers worldwide to adapt to "the most effective and environmentally-friendly seed-sowing tool ever devised", the Cross Slot No-Tillage system. In the words of Victor Hugo, is ..... "an idea whose time has come".

Bruce Ullrich, OBE., B Com., M.B.A., F.Inst.D., CAANZ(Hon)., Hon Professor Shanxi University of TCM., Beijing Open University.

Businessman, entrepreneur, educator, leader & sportsman

References:

Baker, C.J. (2012) No-Tillage Seeding. In *Floreat Scientia, 256 pages (Wairua Press, ISBN 978 1 927 158 081, ed. Paul J., Moughan) Chapter23, pp129-133.*

Baker, C.J. (2015) The Cross Slot® no-tillage story: Taking the risk out of "no-Tillage" seeding. In *Plains Science 2I, ed. V. E. Neall: Royal Society of New Zealand Manawatu Branch, pp 42-60).*

Baker, C.J. McDonald, J.H., Seebeck, K., Rix, C.S. and Griffiths, P.M. (1979) Developments with seed drill coulters for direct drilling: III An improved chisel coulter with trash handling and fertilizer placement capabilities. *New Zealand Journal of Experimental Agriculture 7,* 189–196.

Baker, C.J. Saxton, K.E. and Ritchie, W.R. (1996) No-Tillage Seeding: Science and Practice. *CABI publication, 258 pages,* ISBN 0851991033.

Baker, C. J., Saxton, K. E., Ritchie, W. R., Chamen, W. C. T., Reicosky, D. C., Ribeiro, F., Justice, S. E. and Hobbs, P.R. (2006) No-tillage Seeding in Conservation Agriculture. *CABI publishers, 350 pages. ISBN # 1 84593 116 5. (English, French, Spanish & and Russian translations).*

Borlaug, N.E. (1994) Feeding a human population that increasingly crowds a fragile planet. *Supplement to Transactions of the 15th World Congress of Soil Science. Acapulco, Mexico.*

Ghatohra, A. S. (2012) Effect of method of tillage on loss of carbon from soils. *PhD Thesis, Massey University Library.*

Grabski, A. S., Schafer, B.M. and Desborough. P. J. (1995) A comparison of the impact of 14 years of conventional and no-till cultivation on physical properties and crop yields of a loam soil at Grafton, NSW. *Proceedings of the National Controlled Traffic Conference. Rockhampton, Australia,* pp. 97-102.

Hamilton-Manns, M. (2004) *Unpublished data.*

Leabourn, T.G.E. (2017) Comparison of the Effects of Cross Slot® No-Tillage against Conventional Tillage on Soil Organic Carbon and Nitrogen Stocks. *BAgrSc(hons) dissertation, Massey University Library.*

Pool, N. (2007) Cereal establishment: Is broadcasting an overlooked opportunity? *FAR Information Bulletin, Lincoln, Canterbury, NZ.*

Pool, N. (2011) FAR Arable Site Cultivation Trial 2006-2011. *FAR Information Bulletin, Lincoln, Canterbury, NZ.*

Reicosky, D. C. and Saxton, K.E. (2006) Reduced Environmental Emissions and Carbon Sequestration. In *Baker, C. J., Saxton, K. E., Ritchie, W. R., Chamen, W. C. T., Reicosky, D. C., Ribeiro, F., Justice, S. E. and Hobbs, P.R. (2006). No-tillage Seeding in Conservation Agriculture. CABI publishers, 350 pages. ISBN # 1 84593 116 5, pp 257-267.*

Robinson, G.S. and Cross, M.W. (1957) Overdrilling pumice pastures. *New Zealand Journal of Agriculture* 95, 283–288.

Ross, C.W., Saggar, S., Yeates, G.W., Dando, J., and Shepherd, T.G. (2000) Soil quality under long-term cropping by no-tillage and conventional cultivation, and permanent pasture in the Manawatu. In *Adams, J.A.; Metherell, A.K. (eds) 2000. Proceedings of Soil 2000: New horizons for a new century. Australian and New Zealand second joint soils conference. Vol. 2. 3–8 December 2000, Lincoln Univ. New Zealand Society of Soil Science. pp 251–252.*

Saxton, K. E. and Baker, C. J. (1990). The Cross Slot drill opener for Conservation Tillage. *Proceedings Great Plains Conservation Tillage Symposium, Bismarck, ND, USA, pp. 65-72.*

INFORMATION MEMORANDUM

The influence of Cross Slot® Low-Disturbance-No-Tillage on soil organic carbon and organic nitrogen levels on arable farms in New Zealand

Dr C John Baker and Taylor Leabourn

(March 2020)

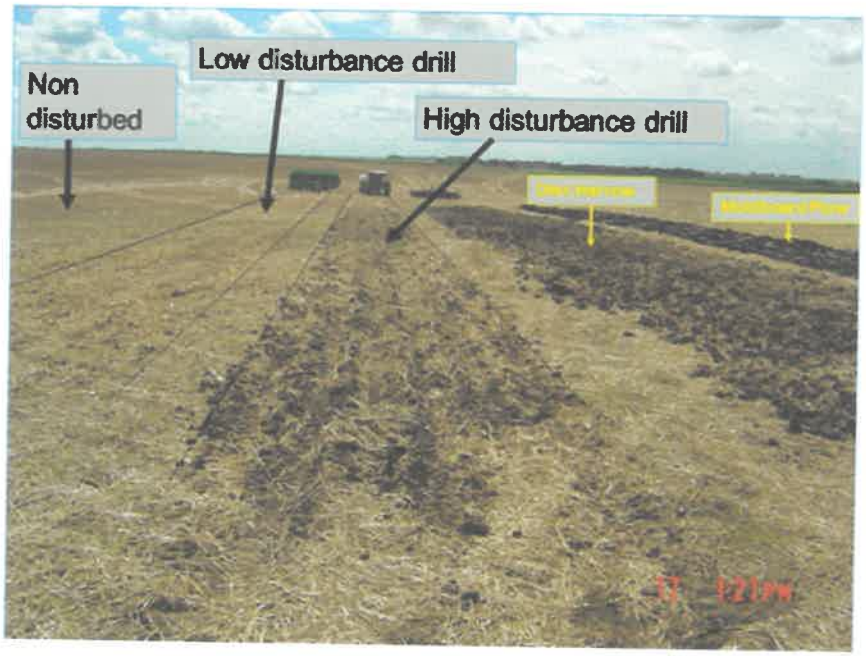
The problem:

- It is well known that the world's soils and oceans are major sinks for the storage of carbon.
- It is also well known that CO_2 discharged into the atmosphere from multiple sources (industrial and natural) is continuously recaptured in nature by the photosynthesis of green plants including agricultural pastures, trees and arable crops as well as wild pastures, trees, shrubs and algae.
- Mankind has control over agricultural plants and cultivated trees but less control over other plants, the oceans or algae.
- This document demonstrates the effectiveness of recycling of atmospheric carbon via agricultural crops and pastures (sometimes referred to as sequestration).

The solution:

- ✓ Conventional cultivation of agricultural soils to establish arable crops is almost invariably carbon-negative during the seedbed preparation and seed-sowing processes because aeration and inversion of soils during tillage oxidizes more labile carbon (into CO_2 that is discharged into the atmosphere) from existing carbon stocks in the soil than can be gained from burial of carbon-rich residues or animal manure on the surface of the ground.
- ✓ The technique of *conservation-tillage* was expected to be carbon-positive, but in practice, most so-called *conservation-tillage* has proven to be carbon-neutral or carbon negative because of the amount of soil disturbance and inversion that is still caused by techniques such as *minimum tillage, strip tillage,* and *vertical tillage.*
- ✓ By definition, the technique of *no-tillage* should have been capable of reducing soil disturbance and inversion and therefore be carbon positive. But farmers' preferences for high-disturbance and soil-inverting no-tillage openers has ensured that this has not been achieved reliably.
- ✓ Besides, farmers' preferences for shank-type openers conflicts with retention of post-harvest residues on the surface of the ground (one of the main sources of carbon for recycling in arable cropping) because the latter cause blockage problems during passage of such openers.
- ✓ The only proven carbon-positive seeding technique so far developed has been *low-disturbance no-tillage (LDNT)* because it almost eliminates soil and residue disturbance altogether. A distinguishing feature is that it is often difficult to see where a *LDNT* machine has passed (see photograph below).
- ✓ The state of-the-art amongst *LDNT* machines is the Cross Slot® brand invented in New Zealand at Massey University in conjunction with Washington State University, The University of Idaho, North Dakota State University and Oregon State University (USA).
- ✓ This device specialises in returning crop residues and the soil on which they come to rest, to approximately the position they occupied before passage of the Cross Slot openers.

- ✓ To achieve this, farmers have had to learn to retain the carbon-rich crop residues after harvest or termination of cover crops or CRP land, and to drill through them with specialist minimal disturbance non-inversion equipment.
- ✓ This requires an extra-ordinary ability of the no-tillage seeding openers (coulters or modules) to (a) physically handle crop residues without blocking or "hair-pinning", (b) avoid inverting the soil in the rows, (c) create a fail-safe environment for seed germination and seedling emergence, and (d) be able to band fertilizer and/or biological cultures separately from, but simultaneously with the seeds.
- ✓ The latter function is necessary to offset competition for nitrogen by the microbes that decompose the carbon- and nitrogen-rich residues.



5 contrasting post-harvest soil disturbance and soil inversion options (following a harvested barley crop) that have measurable effects on carbon and nitrogen emissions from the soil and recapture from the atmosphere (with thanks to D C Reicosky for photograph)

The proof:

- In 2016, a study was conducted at Massey University in New Zealand, measuring soil organic carbon and soil organic nitrogen levels at three universally-standardized soil sampling depths using internationally-accepted sampling and analytical techniques.
- The soils were located on 10 arable farms throughout New Zealand, which is a 3,000 km long temperate-climate country in the Southern Hemisphere.
- Each soil had undergone at least three successive years of either:

    a) Double cropping using Cross Slot® *LDNT* with repeat residue retention, or
    b) Double cropping using conventional tillage with residue removal as required to allow passage of the tillage tools.

- The results have been published and peer reviewed. Original copies are available on request.

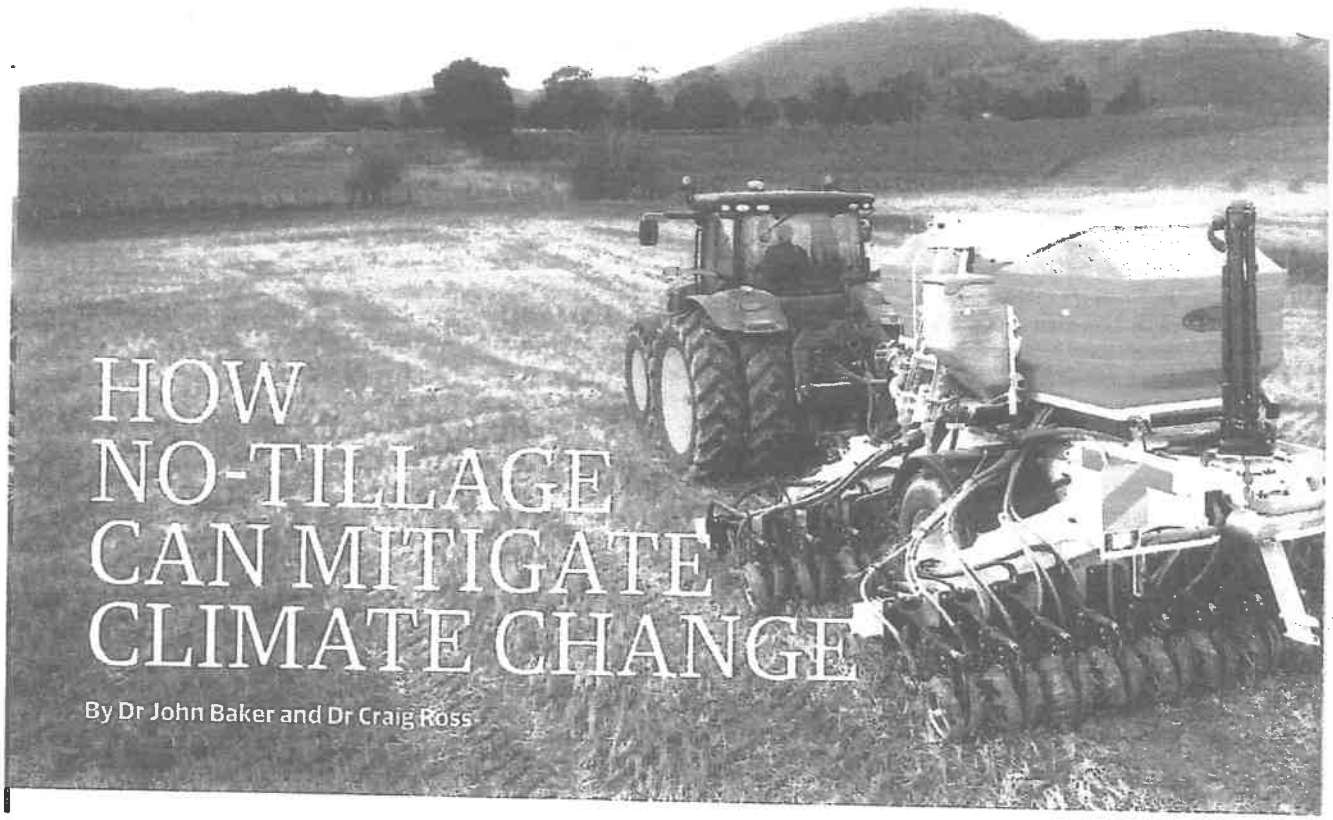
Summary of data:

1. The average organic soil carbon and nitrogen content of 3 consecutive years of Cross Slot LDNT in NZ with full residue return was approximately 30% higher in the top 7.5 cm of soils than for the tilled soils with no residue return.

2. One soil that had had 10 years of Cross Slot LDNT, had 50% more organic C and N than the comparative tilled soil in the same district.

3. The differences were slightly less (20%) but in the same order in the 7.5 to 15 cm soil layer.

4. The differences were slightly less again (15%) but in the same order in the 15 to 30 cm soil layer.



HOW NO-TILLAGE CAN MITIGATE CLIMATE CHANGE

By Dr John Baker and Dr Craig Ross

DR JOHN BAKER, ONZM

Emphasis today is strongly on reducing all of agriculture's Green House Gases (GHG), which include carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). However, few people realise that farming also holds several keys to recapturing a significant amount of, at least, the CO_2 emissions from all sources - CO_2 being the most prevalent of the three GHGs. The extent to which soil is disturbed during the ground preparation and seeding process oxidises soil carbon that escapes into the atmosphere as CO_2.

New Zealand sows about one million hectares of new pastures and crops each year. If all of this was undertaken by low-disturbance no-tillage with full residue-retention, the net emissions of carbon dioxide from the soil would be reduced by about 9.2 million tonnes, according to Ghatohra's research[1]. In fact, the soil would gain about 0.5 million tonnes of new carbon (equivalent to 1.8 million tonnes of carbon dioxide (CO_2) per year.

According to the Ministry for the Environment latest figures[2] New Zealand's total net emissions of GHGs, as of 2015, was 80.2 million tonnes of CO_2-equivalent, of which 48% or 38.4 million tonnes was from agriculture. Applying Ghatohra's research to these figures we have calculated that no tillage could offset about 11% of New Zealand's total net GHG emissions and 24% of agriculture's.

Although it is gathered from the atmosphere, carbon is one of the most essential nutrients of plants. Returning that recaptured-carbon to the soil would not only take some pressure off the need to reduce other GHG emissions but it would also rebuild soil organic matter levels. With that comes improvement in soil health and crop yields, which have deteriorated over time under conventional tillage.

Ghatohra's research at Massey University in 2012[1] showed that sowing agricultural seeds by low-disturbance no-tillage (summer barley followed by winter forage or cover crop, with full residue-retention) could recapture about 1.8 tonnes/ha/yr of carbon dioxide gas from the atmosphere and sequester this back into the soil as solid or liquid carbon. Continuing to till the soil, on the other hand, results in a net carbon dioxide discharge of about 7.4 tonnes/ha/yr. The low-disturbance no-tillage process and rotation can therefore be regarded as carbon-positive as far as the soil is concerned, whereas conventional tillage is always carbon-negative.

In New Zealand, one tonne of harvested grain usually leaves about one tonne of crop residue behind. This is a resource that we have only recently realised the true value of – not just as a relatively modest source of nutrients, but also as a rich source of recyclable carbon.

Recapturing carbon

The process of recapturing atmospheric carbon dioxide gas is based on photosynthesis, which is a fundamental function of all green plants. Photosynthesis converts CO_2 gas from the atmosphere into solid or liquid compounds of carbon such as plant carbohydrates.

Getting the re-captured carbon back into the soil involves three main farm processes:

1. Leaving the residues of dead or dying pastures and crops (including the straw, stubble and dead roots of harvested crops, or entire cover crops, all of which contain about 40% carbon) to decompose on the soil surface where earthworms and other soil fauna incorporate it into the soil free of charge.
2. Allowing the roots of growing crops to transfer some of the carbon directly into the soil as root exudates.
3. Passing the living vegetation through farm animals, which excrete a proportion onto the soil as carbon-rich dung, even though they also belch some of it directly back into the atmosphere as methane gas.

The issue with decomposing

Decomposing residues on the surface of the ground have always been regarded as a nuisance because they interfere with the passage of machinery. So we have been in the habit of disposing of them by one means or another before they decompose. For low-disturbance no-tillage to work, that practice must stop.

What not to do

Burn residues: This discharges most of the CO_2 directly back into the atmosphere and is definitely carbon negative.

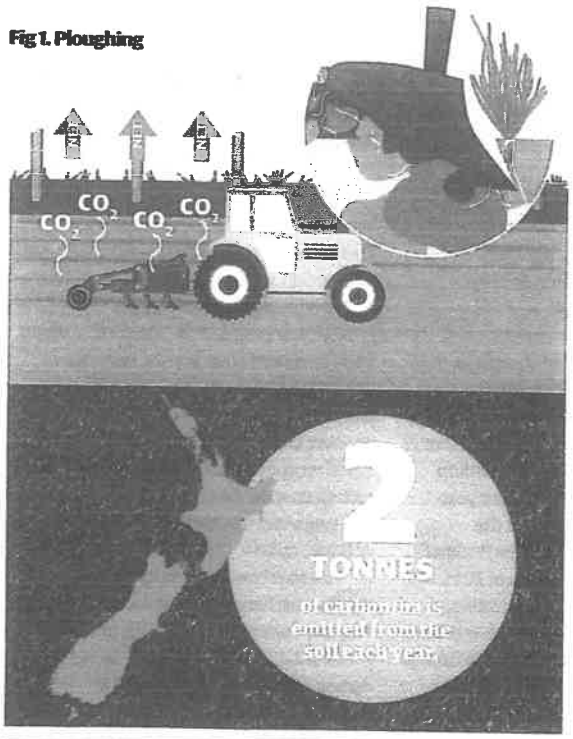
Bury residues: This is largely carbon-negative because in most cases more existing soil carbon is oxidised to CO_2 in the burial process than is gained from the residues being buried.

Acceptable practices

Baling residues: This is less carbon-negative than burning or burial because a portion of the carbon in crop residues is contained in the roots, which of course are not baled or burnt.

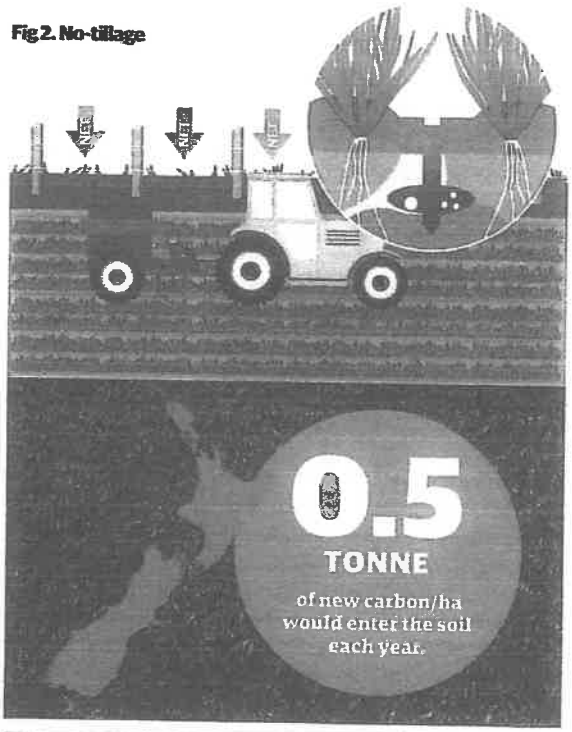
While not all no-tillage machinery is low-disturbance, and some unlikely to be carbon positive, the good news is that the best of the carbon-positive low-disturbance no-tillage seed drills was invented in New Zealand. It has the ability to increase crop yields and profitability at the same time as recapturing soil carbon – surely this is a better solution than the Government paying penalties for not meeting emission targets?

Fig 1. Ploughing



TILLING THE SOIL CONTRIBUTES TO THE AGRICULTURAL INDUSTRY'S TOTAL CO_2 EMISSIONS OF 38.4 MILLION TONNES A YEAR WITH 2 TONNES/HA/YR EMITTED FROM THE SOIL.

Fig 2. No-tillage



NO-TILLAGE CAN REDUCE AGRICULTURAL CO_2 EMISSIONS BY 24% WITH 0.5 TONNES OF NEW CARBON/HA ENTERING THE SOIL EACH YEAR.

(1, 2) see source code on page 40