Productivity Commission
Draft Report on Low-Emissions Economy
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Submission by: Mr C R Hook
Director and CEO
Farmorganix Europe S.R.L
chris@farmorganix.com.au
Mob: +64 21 909 874
www.farmorganix.eu

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The Problem:

Elemental carbon in soil organic matter oxidizes into CO_2 when soil is tilled in preparation for seeding new crops. The CO_2 is released as a greenhouse gas (GHG).

If soil is not tilled, organic matter, which is about 40% carbon, remains under the surface of soil and much less CO_2 is released into the atmosphere.

This is a global issue. The quantity of CO_2 released from this source in New Zealand is in excess of 6 million tonnes of CO_2 e /yr. and represents approximately 7.5% of the country's total emissions.

It is estimated that up to 20% of global GHG emissions are produced by farmers tilling their land to feed the world's inhabitants. With approximately 85% of the world's food coming from arable crops sown each year, *(Borlaug 1994)* CO_2 emissions from this source will remain a perpetual problem unless mankind adopts new technology available now that can substitute for the mouldboard plough.

Centuries of cumulative soil disturbance, worldwide, has caused about 75% of the carbon in organic matter to be oxidized into CO_2, which has been lost to the atmosphere. This has been exacerbated by the fact that arable soils, which provide our food, comprise only 4% of the earth's surface and continue to decline in both area and quality. *(Wikipedia on line, 2017*).

The Solution:

Eliminate CO_2 emissions by not tilling the soil, using technology known as **low disturbance no-tillage ("LDNT").**

Restock the soil with new carbon using LDNT technology to capture the photosynthesized carbon contained in the straw and stubble of arable crops, which are harvested annually, as well as in purpose-grown cover crops. *(Leabourn 2017)*

Background:

LDNT was originally invented at Massey University, is patented, and commercialized to a limited extent by the Cross Slot® Group of companies **("CSG"),** based in Fielding.

Cross Slot technology, which is also the brand name of the machine, is widely recognized within the international scientific and soil-conservation community as the most effective of all no-tillage or conservation tillage systems available anywhere in the world. The science and the Cross Slot machine's functionality has been rigorously examined and peer reviewed by international agricultural scientists and practicing farmers.

The United Nations FAO commissioned a book that was authored by the inventors of Cross Slot and was published in 2006. It remains the leading text on the science of No-tillage *(Baker et al 2006).* Cross Slot technology has been widely acclaimed, is potentially disruptive to multi-national agricultural machinery and tractor manufacturers and their supply chains and is considered capable of making virtually all other crop establishment systems obsolete.

Cross Slot is the only machine available worldwide that can successfully, and repetitively seed and fertilize a new crop in one tractor pass over land that has not been tilled in any way and remains covered by a cover crop or stubble and straw from the previously harvested food or fibre crop.

To date, CSG has only been able to gain a nominal share of the available worldwide market due to financial constraints, high costs associated with very small production volumes, high selling prices, distance from main markets, and the competitive advantage held by major multi-national tractor and agricultural machinery manufacturers.

Furthermore, many farmers have little understanding about soil biology, which is essential to recognize the benefits of adopting Cross Slot technology.

However, more than 160 machines are operating successfully in New Zealand and 20 other countries with the practical performance of the machines in the field being well recognized; particularly in terms of improving crop yields, lowering operating costs, and at the same time regenerating soil health by re-stocking the soil with organic matter. *(Reicosky and Saxton, 2006; Ross et al, 2000)*

Over the last 50 years, various "so called" no-tillage systems have been introduced to the world's farmers, and despite being somewhat rudimentary, approximately 70% of all arable crops grown in Latin America use this method. It has also been widely promoted to farmers in Australia and North America. But Europe has been very slow to make the change.

As evidence of the respect given to Cross Slot technology in the field of no-tillage, Dr C J Baker, Chairman of CSG, addressed a sub-committee of the US Senate in

Washington DC in 1989 on the topic before legislation was passed in 1990 that virtually compelled farmers to adopt no-tillage or lose their eligibility for farm subsidies. Dr. Baker has also been the guest speaker at numerous international conferences on no-tillage including in Latin America.

Cross Slot technology was also a finalist in the 2010 World Technology Awards Challenge held in New York.

All other "so called" no-tillage systems, which are collectively referred to as either **"conservation tillage" ("CT")** or **high disturbance no-tillage ("HDNT"),** and include **"strip tillage",** or **"minimum tillage",** are technically and environmentally inferior to Cross Slot.

New Zealand:

In New Zealand, approximately one (1) million hectares of land is seeded each year, of which about 650,000 hectares are conventionally tilled with 350,000 hectares seeded by one of the several forms of HDNT or CT. *(NZ Agricultural Statistics, 2015).*

About 20% or 70,000 hectares is seeded by LDNT with a Cross Slot, representing about 7% of the total land seeded annually in NZ

New Zealand farmers have access to the most advanced tillage system available, which if adopted widely could make a significant impact on the total CO_2e emissions from agriculture. But there is currently no incentive from Central Government or Regional Councils to do so.

Set out below are detailed assessments of the costs and benefits and a suggested pathway for implementation.

What would be the benefit to New Zealand's emission reduction target if all crops were to be established by LDNT using the Cross Slot system?

Research conducted at Massey University in 2012 has determined that when new crops are established using the Cross Slot LDNT system, with the residue from the previous crop remaining on the soil surface and allowed to decompose, a net 0.5 tonnes/ha of organic carbon can be sequestered back into the soil *(Ghatohra 2012).*

This represents 1.835 tonnes of CO_2e *(based on 1 tonne of elemental carbon being equivalent to 3.67 tonnes of CO_2e*), and is the amount of CO_2 that is taken by photosynthesis from the atmosphere by annual crops, less losses from respiration, decomposition, tractor exhausts, and other sources.

By contrast, conventional tillage is always net carbon negative. The soil releases approximately 2.0 tonnes/ha (net) of organic carbon or 7.34 tonnes of CO_2e into the atmosphere each time a new crop or pasture is sown using conventional tillage through excessive air being introduced into the soil. *(Ghatohra 2012).*

Thus, we can say that the adoption of LDNT using the Cross Slot system by farmers who currently use conventional tillage, would reduce CO_2e emissions by approximately 9.2 tonnes/ha each year.

Applying this to 650,000 hectares of land that is conventionally tilled in NZ and we can say that CO_2e emissions would reduce by approximately 6.0 million tonnes each year. (9.2 x 650,000).

CT and HDNT systems have not been scientifically evaluated to determine their effect on CO_2 emissions, but because they disturb the soil significantly more than Cross Slot LDNT it is likely they are at best carbon neutral and even carbon negative at times. For the purpose of this evaluation it is assumed they are carbon neutral.

Given New Zealand's global decarbonizing commitment under the Paris Agreement, what is the value of 6 million tonnes of CO_2e?

The transition models prepared by Vivid Economics and Motu Economic & Public Policy Research suggest that New Zealand can move to net zero emissions in the second half of this century with a price of between NZD 75 and NZD 150 /t CO_2e, and reach a more stringent net zero emissions constraint by 2050 with an emissions price of between NZD 150 and NZD 250/tCO_2e.

This future estimated cost for emitting CO_2e provides a huge incentive for all farmers currently using conventional tillage systems to convert to LDNT using the Cross Slot system, regardless of whether or not agriculture is included in the Emissions Trading Scheme.

Capital cost to adopt LDNT with the Cross Slot system:

A reasonable assumption would be that one Cross Slot machine is required per 1,000 hectares of land, with each machine priced to farmers at NZD 250,000 (ex GST).

Given an emission price of NZD75/t CO_2e or more by 2050 it is assumed that all farmers who use conventional tillage will convert to LDNT by investing in a Cross Slot machine or similar if competing brands have by then learnt how to emulate the capabilities of the Cross Slot system without infringing patents, or negotiate with CSG for a license to use the Cross Slot patents.

The total capital outlay would be approximately NZD 160 million (ex GST), which is a small investment when considered in terms of the benefits that will result, both directly and indirectly, (650 machines x NZD 250,000 each).

The capital outlay would increase to approximately NZD 250 million if all farmers who seed land (including those who use other no-tillage systems) decide to convert to LDNT with a Cross Slot.

Financial benefit for farmers who adopted LDNT with the Cross Slot System:

Establishing crops and pasture with the Cross Slot LDNT system involves a single tractor pass over the land sowing through the residue from the previous crop lying on the surface, with both seed and fertilizer being placed simultaneously in optimal positions for germination and growth.

Cross Slot is the only machine available worldwide that is capable of doing this without creating other unacceptable problems. (blocking by the residue, hairpins etc). Other no-tillage systems cannot adequately handle the previous crop residue in place, or simultaneously place fertilizer in the optimal position for utilization by the growing plant.

The benefits of LDNT seeding with the Cross Slot system can be summarized as follows:

Cumulative regeneration of soil health for sustainability.
Opportunity to use the best soil for growing arable crops year after year.
Lower input costs to grow crops and new pasture (seeds, fertilizer, tractor operations).
Increased crop and pasture yields.
Increased farm incomes and flow-on benefits for New Zealand's economy.
Increased value of farmland due to soil having a higher organic matter content.
Less irrigation water required to grow crops.
Lower CO_2 emissions into the atmosphere
Additional economic activity from manufacturing of Cross Slot machines.
International revenues from sale of Cross Slot machines and licenses.
Increase in Government tax revenue
Increase in New Zealand's GNP.

Farm operating cost reductions will result from:

Lower tractor operator labour cost.
Lower diesel fuel consumption of tractors and less air pollution from exhausts.
Lower tractor maintenance costs – less operating hours required to establish crops.
Lower investment in agricultural machinery over the long-term.

Because of the range of tillage systems used in New Zealand it is difficult to calculate an average cost saving without making a detailed analysis of land areas tilled by each system, and knowing actual input costs.

However, a practical way to estimate the financial benefit from the adoption of LDNT with the Cross Slot system is to compare the cost to establish crops under conventional tillage with Cross Slot LDNT. These are approximately as follows;

Conventional tillage	NZD 400/ha
Cross Slot LDNT	NZD 200/ha

The difference of $200 /ha becomes a substantial sum when applied to the 650,000 ha's of seeding currently undertaken each year using conventional tillage. (*N.B. The prices quoted do not include the cost of fertilizer, seeds, or plant protection products - herbicides and pesticides).*

If 650,000 hectares of conventionally tilled land is converted to LDNT with Cross Slot machines the total reduction in farm operating costs will approximate NZD 130 million. (650,000 ha x NZD 200/ha).

This total would increase significantly if those farming the remaining 350,000 hectares converted from their CT or HDNT system to the Cross Slot LDNT system.

Reduction in seed cost:

Statistics published by the USDA say that the average germination rate for crops under conventional tillage, CT and HDNT in the United States is approximately 65%.

With the Cross Slot LDNT system, seed germination rates regularly exceed 90% and there is much evidence available to confirm this.

Again, it is difficult to establish a cost saving because of many variables in seed prices, the number of kgs of seed applied/ha, and tillage system used.

However, the saving in seed cost with the Cross Slot system is estimated to be in the range of NZD 20/ha to NZD 40/ha.

Adopting the low end of this range, NZD 20/ha applied to 650,000 hectares would result in a cost saving of NZD13.0 million per annum.

The reasons for a higher germination rate under LDNT with a Cross Slot are that soil humidity is retained in the soil pore spaces between particles and both seed and fertilizer are placed in optimal positons for the seed to germinate and grow.

All soil disturbance allows poor-space soil humidity to escape into the atmosphere, which is why germination rates are generally lower with conventional tillage and most other CT or HDNT systems.

Increase in crop yield:

There is much evidence available to confirm that yield increases are almost invariably achieved when crops are established with Cross Slot LDNT compared with the same crop grown by any other tillage system. Climatic conditions cause plants to stress, but they are less affected when grown with Cross Slot LDNT. *(Saxton and Baker, 1990, Hamilton-Manns, 2004).*

While a 10% yield increase with a Cross Slot is adopted here, users of Cross Slot systems and independent scientists regularly report significantly higher yield

increases. These range from 15% in a 7 year USDA wheat trial, to 30% in a 14 year soybean trial in Australia. *(Grabski et al, 1995).* In New Zealand, the Foundation for Arable Research conducted a multi-year wheat trial and achieved a 20% yield increase compared with a control grown by conventional tillage. (*Poole, 2011).*

Dr. C. J. Baker of CSG has advised that there are anecdotal examples from Taranaki and the Waikato where turnip yields have doubled using Cross Slot LDNT.

An attachment to this submission is a summary of various formal trials conducted in NZ, Australia, and USA which supports the above statements. These results can be validated by reference to a significant bank of data available from users in 20 countries worldwide where Cross Slot machines operate.

Seeded crops in New Zealand are grown for sale as commodities (e.g. wheat and barley), stock feed (e.g. maize) and as new pastures. Since prices for these vary it is difficult to establish an accurate average value without making a detailed analysis.

This submission has assumed an average arable crop yield of 7.0 tonnes/ha under conventional tillage and a net price/value to the farmer of NZD 250/t. An arable crop area of 200,000 hectares is also assumed - (out of the total of one (1) million hectares seeded annually).

Assuming a 10% yield increase or 700kg/ha when crops are established with a Cross Slot LDNT, the additional value per hectare is NZD 175 and an estimated revenue/value increase for farmers of NZD 35 million (from 200,000 hectares).

Supporting data from a 2011 field trial conducted in Canterbury by the New Zealand Foundation for Arable Research ("FAR").

A summary of a comprehensive wheat trial conducted by FAR is provided in support of the statements and estimates made here with regards to yield increase, crop establishment costs, increase in revenue from the crop, and recovery of the cost of a Cross Slot machine.

This information is independent scientific evidence supporting the "averages" used herein to determine the estimated overall benefit if New Zealand arable farmers convert from conventional tillage to LDNT with a Cross Slot.

In the table of six (6) different crop establishment systems trialed by FAR, we focus on Treatments 1 and 5, which are highlighted, being the comparison between conventional tillage with four (4) tractor passes, and LDNT with one (1) pass by a Cross Slot.

Cross Slot outperformed conventional tillage in every respect:

Yield increase - 11.7% and additional gross crop revenue of $720/ha.

Establishment Cost/ha - the Cross Slot single pass system cost 49% of the conventional tillage system.

NB: The variance between contractors' costs and the costs used by FAR is likely to be due to farmers not attributing full tractor or labour costs in their calculation. (e.g tractor depreciation, long-term maintenance charges, or cost of capital involved).

Combined benefit of increased revenue and lower costs - NZD 839/ha.

Recovery of Cost of the Cross Slot machine – for a typical arable farm of 300 hectares, for this crop and the assumed price of NZD 300/t received by the farmer the benefit would amount to NZD 251,700, which would fully recover the estimated cost of the Cross Slot machine, operating at less than 50% of its theoretical annual capacity. (We have said that a Cross Slot with an annual seeding capacity of 1,000 hectares would cost NZD 250,000 in 2018 dollars).

Cross Slot machines are available in a range of sizes and optimal size for a particular farm will depend on how much land is seeded each season.

Another point to note is that this FAR trial was conducted on a high yielding property and compares with typical winter wheat yields achieved in Europe of between 5 and 12 tonnes/ha. The five (5) year average data from an experienced farmer in England (2012-2016) growing wheat has produced 8.74 tonnes/ha.

Farms producing comparatively low yields/ha can likely achieve significantly higher yield increases with a Cross Slot than what is typically achieved by New Zealand's wheat farmers.

FAR says that the average wheat yield in New Zealand in 2017 was 9t/ha, and it is interesting to note that they have an R & D programme called "20 by 2020" which aims for wheat yields to 20t/ha.

Reduction in fertilizer usage and cost:

This is achieved by the Cross Slot system for two reasons;

Soil organic matter increases through sequestration of carbon and thus the fertility and productive capacity of soil increases over time, requiring lower application rates of chemical fertilizer to grow crops. A survey by Massey University in 2016 showed that this is already occurring on a farm scale throughout the country.

With the Cross Slot system, fertilizer is incorporated into the soil, and placed adjacent to the seed in the optimal position to promote germination and growth without causing seed damage.

Many HDNT systems cannot place fertilizer below the soil surface at the time of seeding, or as accurately and targeted as the Cross Slot system. With HDNT, fertilizer is often left too far from the seed to be effective or placed too close, with the risk of adversely affecting seed germination.

There is considerable scientific evidence confirming that at up to 50% of NPK fertilizer broadcast onto the surface of tilled soil during seed bed preparation is lost into the environment, which is avoided when incorporated into the soil with a Cross Slot at the time of seeding.

It is reasonable to assume an average NPK application rate of 150kg/ha for most crops and pasture although this varies considerably depending on the crop to be grown and the nutrient content of the soil prior to seeding.

Dairy pasture typically receives 200 to 300kg/ha/yr of NPK or nitrogen, with sheep and cattle pasture receiving less.

Vegetables such as field tomatoes, potatoes, and corn (maize) require heavy application rates of NPK because of the plants high nutrient demands but it is well established scientifically that crop yields can be maintained (and generally increased) if up to 50% of the inorganic fertilizer application is replaced with new-generation organic biological products that are now readily available.

For these crops, standard inorganic fertilizer application rates are frequently in the range of 700kg/ha, and can be as high as 1.5t/ha.

I have been involved with a number of scientific trials in Europe where 50% of the standard chemical fertilizer application was replaced with 10 litres/ha of a biological product, at a lower cost, and I am aware of soil inoculants now available in Europe which produce similar results with arable crops. These inoculants have the equivalent value to approximately100kgs/ha of NPK and are significantly cheaper than the equivalent inorganic NPK.

Biological fertilizers allow plants to access atmospheric nitrogen, and unbind some of the phosphorus and potassium in the soil that plants cannot otherwise access. This is the fundamental reason why crop yields can be maintained with significantly lower application rates of inorganic fertilizers.

Given the high soil humidity environment that is retained, Cross Slot LDNT machines are the perfect complement to such “new-age” fertilizers.

For 650,000 hectares of conventionally tilled soil, it is assumed that a total of approximately 100,000 tonnes of inorganic fertilizer is applied each year at the rate of 150kg/ha, of which up to 50,000 tonnes is lost into the environment.

At an assumed average cost to the farmer of NZD 300 per tonne, (including application), the total cost of inorganic fertilizer applied is about NZD 30 million, of which up to NZD 15.0 million provides no economic value.

Chemical fertilizer that leaches from land finds its way into underground aquifers, streams, rivers and lakes, polluting the country’s freshwater resources. This has become a significant environmental problem and is now recognized to require huge expenditure to remediate.

This submission is not intended to address the issue of chemical fertilizer v biological fertilizers and soil inoculants, but attached is an informative article published recently by Pure Advantage and authored by Phyllis Tichinin, a recognized expert in soil fertility, environmental management, and biology as applied to agriculture.
She is quoted on page 3 saying *"it is the types of fertilizers we're using (chemicals) that are causing most of agriculture's impact (negative) on the environment and that includes dairying"*.

There is well established scientific evidence and a sound economic case that supports the need to significantly reduce the consumption of chemical fertilizer, and pesticides if New Zealand is to achieve the goal of becoming a low-emissions economy.

Increase in the capital value of farmland:

Soil organic matter is arguably the most important component of soil influencing its structure, water holding capacity, stability, nutrient storage and turnover, porosity and oxygen holding capacity; properties that are fundamental to maintaining and improving soil quality, and its crop yielding capability. *(Smil V.1999).*

The Cross Slot system is the only one that has been proven to regularly sequester carbon in untilled soil, and with the carbon content of organic matter ranging from 40% to 50%, as much as one (1) tonne of organic matter/ha can be added to soil each year when seeded with a Cross Slot.

Arable land therefore becomes more productive over time, (rather than less) and its market value increases. This has been assessed in both New Zealand the USA and I attach a relevant article on this subject published by the USDA.

Insurance against unexpected and extreme weather events:

Farming is becoming an increasingly risky business, and in recent years they have had to deal with frequent abnormal weather events, predominantly storms and droughts.

Experts predict that such events will increase in frequency and intensity in future years, making it necessary for farm management practices to change in order to protect and enhance the quality of the country's soil, which is one of New Zealand's most precious natural resources. Growing high yielding crops each year is also important for sustaining and increasing food production volumes, incomes for farmers, and income for the economy.

Unseasonal wet weather can delay or prevent crops and pastures from being established as wet tilled soil quickly turns to mud.

Strip till and most HDNT systems struggle to operate in wet soils while Cross Slot machines have much wider tolerances and can operate successfully in most conditions when soil is not tilled.

When tilled soil is exposed to heavy rainfall events the surface readily erodes, carrying inorganic fertilizer and pesticides into waterways.

This is a global problem, and is responsible for vast amounts of productive top soil and nutrients being lost into streams and rivers, much of which eventually ends up silting estuaries, harbours, and the seas adjacent to river mouths. This is creating another set of ecological problems that can be avoided by LDNT.

The residue from previous crops is beneficial to establishing new crops and pastures. It slows the velocity of eroding water and wind, increases water infiltration, suppresses weeds, provides protection for the emerging seedlings, and helps retain moisture in the soil. When residues decompose, they return nutrients and organic matter to the soil.

In times of drought, or when seasonal rains have not arrived by the time farmers want to seed new crops into tilled soil they must risk planting into dry soil in the hope that rain will arrive in time to germinate the seed. The only other option is not to plant at all, which means no crop, no production, and a heavy financial penalty for the farmer.

However, when seeding is undertaken into undisturbed soil with a Cross Slot, soil humidity is retained, which is sufficient for seeds to germinate and emerge, even when limited moisture is available.

Soil that has not been tilled, but has full residue from the previous crop lying on the surface has higher moisture content. As a consequence germination and crop establishment is virtually guaranteed. But only Cross Slot machines can facilitate this without creating unintended downsides such as “hair pinning” or “tucking” of bent over straw into the seed zone that can ferment into acetic acid, which kills seeds and seedlings.

As fresh water and food supply are becoming two of the world’s most serious problems LDNT can be expected to become the most dominant food production method, in the same way the mouldboard plow did in the past.

Since the Cross Slot system is a tool invented in New Zealand farmers can either adopt it over the next 5-10 years or react as will be necessary when the price of CO_2e is finally set for all emitters.

Summary of costs and benefits if 650,000 hectares of tilled land is converted to LDNT with a Cross Slot:

	NZD
Estimated capital cost of 650 Cross Slot machines	160,000,000
	=========

Annual direct benefits from the conversion of 650,000 hectares of land currently under conventional tillage to LDNT with the Cross Slot system.

	NZD
Reduction in farm operating costs	130,000,000
Reduction in seed cost	13,000,000
Reduction in fertilizer	15,000,000
Additional value of crop yield	35,000,000
Total	193,000,000
	=========

The capital outlay of NZD 250,000 for each Cross Slot machine will be recovered from cost savings and benefits in their first full year of operation assuming each machine is used to seed 1,000 hectares.

The actual savings and benefits will vary from farm to farm, but on average the capital outlaid on each new Cross Slot machine should self-fund in approximately one year of operation, and will produce a significant additional positive cash flow for the farmer every year thereafter.

When viewed overall as a sector of the economy, the adoption of Cross Slot technology for all land that is seeded (approximately one (1) million hectares) will likely provide additional revenue in excess of NZD 300 million each year with flow-on benefits for New Zealand's economy.

Carbon Trading Scheme

The above direct benefits for farmers who convert to LDNT with the Cross Slot system do not reflect the value of CO_2e saved of NZD 900 million in 2050 that would otherwise have to be paid if NZD 150/t of CO_2e is the price that is fixed at that date.

It is assumed that farmers will convert to LDNT with Cross Slot machines and reduce CO_2e emissions by approximately 6 million tonnes per annum, which will make a valuable contribution to New Zealand becoming a low-emissions economy.

If all farmers who sow seed adopt Cross Slot technology, (which as stated above is carbon positive to the value of 1.835 t/ha of CO_2e each year) 650,000 hectares will generate carbon credits of approximately NZD 180 million per year at the price/value of NZD 150/t of CO_2e, or NZD 90 million at a price of NZD 75/tCO_2 equivalents.

Why have New Zealand farmers not adopted Cross Slot technology in greater numbers?

Perhaps the most important reason is that very few farmers, or indeed others involved with agriculture, understand the direct and indirect financial benefits that are achieved when crops are established with Cross Slot LDNT, nor have they had a need to investigate the benefits in depth.

Another reason is that many farmers lack the capital required to purchase an expensive machine that only operates for short periods in the spring and autumn seeding seasons.

A third reason is that farmers are not focused on 2030, let alone 2050 and beyond, and do not appreciate the contribution they can make to decarbonizing the economy with LDNT, or the likely financial cost associated with continuing to emit present levels of CO_2e.

How can the Cross Slot Group produce and supply 650 to 1,000 machines within (say) 5 years?

CSG is a small private company that is not resourced to either develop the market without support, or build a large number of machines within (say) 5 years. It has always out sourced all manufacturing to larger organizations. Therefore expansion would not require a significant injection of capital into plant and equipment in one place, but would be spread regionally across NZ.

Capital should be available from private sources once there is a commitment from sufficient farmers to transition to the LDNT Cross Slot system, and some support from Government.

However, this will not happen quickly without farmers being made aware of the benefits and having an understanding of the likely financial burden they will face in 2050 (or sooner) if their CO_2e emissions are not reduced.

Conversion from conventional tillage to LDNT with the Cross Slot system is something that does not need to wait. A programme can be implemented with an almost immediate commencement date, once all elements are agreed and published.

The transition can be completed by 2030, if not earlier. There are 60 Cross Slot machines already operating in New Zealand, and their users can already provide the all-important knowledge base.

How to implement a programme to convert farmers to LDNT with Cross Slot technology?

There are several pathways for implementation, with the fundamental requirement being to create a demand for Cross Slot machines through targeted communication and incentives for farmers, support from recognized agricultural scientists, and for farmers to have access to the capital required to purchase machines.

This is a sufficiently important and viable project for its implementation to be supported by Government and farmers need to clearly understand the benefits they will receive and the contribution they will make to achieving New Zealand's decarbonizing objectives by 2050.

Such a move would fit the definition of new infrastructure and there are various examples of government and private enterprise co-operating to implement significant programmes of this nature.

It seems obvious that once affected farmers appreciate the likely future cost of not changing from conventional tillage to LDNT with a Cross Slot machines there will be very few, if any, who will not want to convert. After all, almost everyone converted to mouldboard ploughing when it was first introduced to agriculture.

CSG has access to the necessary factory space and personnel with the skill sets required to increase production of the machines in co-operation with a number of local and overseas component manufacturers.

Long-term international benefits if all seeding of agricultural land in New Zealand is undertaken with LDNT Cross Slot technology?

Assessments have been made of the potential demand for LDNT technology in North America, Europe, and the Russian Federation. (South America, Africa, Middle East, and China not included).

Australia is another market that could absorb several thousand Cross Slot machines, which would be supplied from New Zealand, and its Government has to date had a more pro-active approach to emission reductions than New Zealand.

The total available market worldwide is more than 300,000 machines, and the revenue from an expanded local manufacturing operation, participation in overseas manufacturing operations, or from royalties flowing back to New Zealand would provide a significant benefit to the economy. The Fisher and Paykel model is a good example of how this can work to New Zealand's advantage.

New Zealand is widely recognized for its innovations in agriculture, and the wide adoption of LDNT with Cross Slot technology that is backed by our agricultural scientists and Government would soon receive international recognition and support in many countries, and from the EU and United Nations.

Such recognition could reasonably be expected to result in other countries adopting similar programmes to New Zealand within their agricultural sectors.

Even now, in some EU countries, farmers who purchase a Cross Slot machine (or any other LDNT machine) can apply for an incentive in the form of a capital rebate of up to 40% of the cost of the machine.

In fact, several Cross Slot users within the EU have received grants of 40% in recognition of the environments benefits provided by Cross Slot technology, and similar incentives are also available in Australia.

There is a huge global market for Cross Slot technology, and an initiative involving the transition to LDNT taken by New Zealand under its decarbonizing programme will almost certainly result in the development of a substantial domestic and export manufacturing operation, create a significant number of new jobs, and there is the likelihood of licenses being taken up by companies in the major agricultural economies to manufacture and supply Cross Slot machines.

Wider international recognition would result if the large multi-national agricultural machinery manufacturers such as John Deere, and Case New Holland incorporated the patented Cross Slot "opener" into their own machines for global distribution.

What are the main international challenges to Cross Slot machines and or the patented opener becoming the industry "standard" that is widely adopted for establishing crops under LDNT?

The global supply of tractors and machinery is dominated by large US and European multi-nationals that control their supply chain, through to financing new sales and trading used equipment.

John Deere and Case New Holland are prime examples of such multi-nationals whose principal business is to manufacture, sell, and service tractors along with agricultural machinery for tilling land and harvesting crops.

These multi-nationals have a conflict of interest and are not expected to support Cross Slot technology until they have to, because wide adoption of LDNT is counter-productive to short-term demand for new tractors, and the various forms of tillage equipment that keep their factories running.

The reasons for this are fairly obvious. A crop which is established in a single pass over the field by a Cross Slot machine requires approximately 20% of the tractor energy (measured more in numbers of tractors rather than horsepower) than it would if it had been established by conventional tillage.

Tractors are designed to have a working life of about 10 years based on an average number of engine operating hours per year, and will therefore last up to 5 times as long before needing to be replaced when used in conjunction with a Cross Slot to establish crops. Revenues from regular servicing and supplying replacement parts will also decline significantly.

The Commission's draft report

The draft report opens by saying that its inquiry is guided by opportunities for the New Zealand economy to maximize benefits and minimize the costs of transition to a low net-emissions economy.

With regard to agriculture it says "*New Zealand will need to be actively involved in developing solutions. Substantially more and better targeted funding for innovation and technology adoption that supports the low-emissions transition is critical*".

The need to reduce emissions is well understood by the "captains of industry" and the public in general following the Government's recent announcements; in particular that oil exploration is to cease, new plantation forests are to be established and electrification of the transport industry is to gather pace.

Agriculture is a significantly difficult sector to deal with, but before requiring dairy farmers to reduce their herd sizes in sensitive environmental areas, (as suggested recently by the Hon. David Parker, Minister for the Environment) a full and proper evaluation of the benefits from reducing the consumption of inorganic fertilizer needs to be undertaken, which is the subject discussed in my previous submission.

Another bold action worth considering?

An initiative that the Commission and Government might consider in the light of the above submissions is assisted transition of existing dairy farms in sensitive environmental areas back to arable crop production, as an alternative to requiring farmers to reduce cow numbers.

This would contribute to solving the present high emissions from the dairy industry, and those who do convert and adopt LDNT would remain profitable and become carbon positive.

Even though numbers of farmers have already done this, the economic impact of widespread change would need to be carefully evaluated before such a radical programme was put into effect. There will always be more global demand for arable crops, than animal products, and at this point in time the country cannot produce enough arable crops to meet domestic demand while at the same time producing vast surpluses of animal products.

Forestry

Forestry is also capable of removing similar amounts of CO_2 from the atmosphere as agricultural crops for any given land area, but they target different classes of land, making them complimentary. Food crops have the advantages however, of providing food at the same time as photosynthesizing new carbon for sequestration into the soil annually.

Under the plan to increase plantation forests there is a substantial capital cost, and for privately owned land it is presumed compensation will be paid on an annual basis pending the trees being harvested in about 20-30 years' time. From an economic perspective, are we sure that this is a superior option to converting all soils which are currently tilled to LDNT?

Summary

Converting all tractorable tilled land to LDNT is a significant *"bold action"* that could be implemented with Government support over the next 5-10 years.

Implementing a policy that requires all land to be seeded under LDNT (unless an official permit to till an area is issued for a legitimate reason such as to repair the ground surface after drainage etc.) would be a logical move as there are only long-term benefits in doing so.

Transitioning to seeding by LDNT is a specific opportunity to reduce GHG emissions from agriculture by a minimum of 6 million tonnes of CO_2e each year, using New Zealand's own Cross Slot system, which is available now although CSG would need to significantly increase the number of machines it can produce each year.

By reducing New Zealand's carbon footprint in the amount of six (6) million tonnes of CO_2e, it will have an effective value of NZD 900 million per year if the price of one (1) tonne of CO_2e in 2050 is NZD 150.

After transition to LDNT with Cross Slot technology gross revenue from all farms that currently till soil will increase by approximately NZD 200 million per annum.

If by 2050, 650,000 hectares of land is seeded with a Cross Slot and the price/value of CO_2e is NZD 150/t farmers will receive carbon credits that can be traded with a value of approximately NZD 180 million. This figure increases to NZD 250 million if all one (1) million hectares of seeded land is established with a Cross Slot.

Adding this to the annual on-farm benefits in the table above will mean a total economic gain for the farmers of up to NZD 500 million.

Unless seeding of land transitions to LDNT, even at the lower price estimate of NZD 75/t of CO_2e, prime productive land currently growing food crops would become uneconomic, and changes would have to be made to the way in which crops are established; or otherwise the land use would need to change.

If LDNT with the Cross Slot system is adopted, there will be flow-on benefits by way of increased volume and value of food production, increased farm profitability and increased capital value of farmland.

For New Zealand, there will be increased economic activity manufacturing the Cross Slot machines, additional export income, additional tax revenue, and a meaningful increase in GDP.

And above all – New Zealand will have demonstrated a model that most of the rest of the world could follow and benefit economically from doing so.

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Attachments:

Papers by:

USDA on the "Value of Soil Organic Matter"
Dr. C.J Baker on "Mitigating Climate Change by Low-Disturbance No-Tillage"
Phyllis Tichinin under the title "Sacred Cows of Agriculture"
Outstanding Wheat Yields by no-tillage - a Summary of finding by FAR
International crop yield comparisons – New Zealand, Australia, and USA