

Chisel ploughing has many merits like almost doubling crop production.

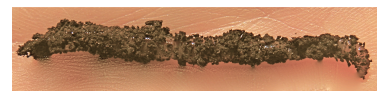
Repeated rotary cultivation destroys soil structures & earthworms.

Chisel ploughing and sowing crops, new pastures or whatever, within a day or two, reduces carbon, humus and moisture loss, all causes of the USA Dustbowl decades ago. Man's first cultivation tool was a wooden chisel plough made from a bent tree or root, pulled by man, then by oxen, later horses and 60 years ago chisel ploughs of steel pulled by tractors.

The mouldboard plough was stupidly developed to bury the existing vegetation, leaving exposed bare soil for the sun to burn humus and to be beaten by downpours of rain, that if on a slope eroded it. Mouldboard ploughing in spring brings up lower-temperature soils and turns down warm soils, delaying the sowing of warm-loving plants such as spring sown crops and pastures. It also buries the top aerobic soil microbes and exposes anaerobic ones, which is negative.

Digging into soils which were mouldboard ploughed have shown lime in a layer upside down, with large clods of dead soil in the middle, because lime was not mixed into it. I've seen clover roots follow the mouldboard furrow joins down to the horizontal layers where lime lay, and nodulating thickly there, and avoiding parts of the soil where no lime had been mixed in. This showed that more lime was needed and that it needs to be chisel ploughed in. 90% of NZ soils don't have enough earthworms, so ploughed down vegetation lies in a layer, which restricts root and moisture movement up and down. These faults give some 'no-till' advantages that chisel ploughing eliminates completely, and beats.

Disc ploughing was developed to be easier to pull and to break up the soil without causing hard pans, and while it is better than mouldboard ploughing, it is not as good as chisel ploughing which is quicker so cheaper. I've seen mouldboard and disc ploughed paddocks revert to a weedy compact condition because the lime was not well enough mixed into the soil. Rotary cultivation mixes lime in, but only to a shallow depth, and damages the soil structure, causing the soil to be fluffed up and later to become compact, partly because of killing all the earthworms. Ruakura Research Centre had rotary hoed for turnips and got a yield of only 5 tonnes/ha instead of the local average of 12 tonnes, so in their ignorance discouraged farmers from growing summer forage crops, for 12 years, which caused disasters in the 2010 to 2015 dry summers. Their bad rotary cultivation on their new AgResearch Lye Farm caused shallow rooted pastures like this peaty soil held upside down to show pasture roots (white ones) growing horizontally at 15 cm because rotary hoeing was to that depth, below which the raw peat would be too acid for ryegrasses and clovers. The fibrous raw peat and almost no earthworms showed that at least 8 tonnes/ha (4 times more than was applied) of LimeMagPlus were needed to be chisel ploughed in to 40 cm.



Three of their scientists came to our Greenhill Road farm, 2 km from Ruakura and asked what we were doing because in late March our farm was green and growing while Ruakura and our neighbours were brown.

I told them, "We applied 8 tonnes of LimeMagPlus per hectare, chisel ploughed it in to 40 cm, Auriel bred and spread earthworms, which they saw made the pasture greener and longer".

This earthworm, was the only one we found in the DairyNZ Lye Farm paddock. It had so much soil stuck to it that it was almost dead, showing a very severe deficiency of calcium. What cruelty. See Soils > Earthworms. The manager of AgResearch Lye Farm should know that such low calcium is also locking up costly P and cobalt. At a DairyNZ field day in November 2010 on Scott Farm across the Vaile Road, I heard their scientist say how difficult peat was to manage. He had obviously not read GrazingInfo's Soils > Cultivation or the 80 pages on Peat, in Soils > Peat. Peat farming is easy and highly profitable. Read Peat, and drive around the Waikato in dry weather to see correctly farmed peat pastures green and growing, then in wet weather to see no pugging in correctly half metre deep spinner drained peat. Had they applied 8 tonnes (3 tons per acre) of LimeMagPlus they would not be having to expensively recultivate and resow their Lye and Scott Farms' peat soils so often, and would not suffer

any ryegrass pulling.

A major cause of this costly mistake is the ignorant policy of not applying lime to the surface of peat pastures, because of a Ruakura faulty trial in 1955 by Frank van der Elst on Rukuhia deep peat swamp of raw peat containing no earthworms. I saw the trial before buying 60 ha of peat. Faults were -

- The lime was hard and coarse, making some to not be available for decades.
- Not enough fine soft lime was applied with serpentine and boron.
- The 8 t/ha (3 tons/acre) should have been chisel ploughed in twice to 40 cm and then one tonne of correct fertiliser per hectare chisel ploughed in once and then 3 t/ha (1 ton/acre) of fine lime applied on the surface and harrowed in to 10 to 20 cm before sowing. Read 'Peat' in Soils. The report to never apply lime to the surface of peat pastures was completely wrong, and lost peat farmers collectively, millions of dollars.

Chisel ploughing

Chisel ploughing saves tractor time and fuel and gives far better results than other forms of cultivation.

At my request, client Owen Baker in 1993, a Matangi, Waikato farmer, did chisel ploughing comparative trials on his loam soil. He was changing from growing vegetables with mouldboard ploughing for years, to growing and grazing pastures. The cropping for years had lowered his soil's organic matter content, so ryegrass didn't do well until grazing with its returned animal manure increased the soil's organic matter content.

His mouldboard ploughed soil shown on the above right shows grass and clover roots not going below the plough depth, because of aluminium and/or a lack of LimeMagPlus and organic matter in the case of perennial ryegrasses. Both areas were cultivated at about the same time and the photos were taken within minutes of each other. Many other trials found the same. When the spade spits were turned over the mouldboard soil above stayed in a lump while the chisel ploughed soil broke up, was crumbly, mixed and friable with roots going to the bottom.



Subsoils in the Waikato that I've had analysed had sodium and magnesium, but less of other known elements, however, like all subsoils, have minerals we don't even know about. Ruakura staff acknowledged this mineral deficiency on their Lye Farm and on others, where animals eat subsoils for its minerals because of incomplete fertilisers and not feeding the nine lacking minerals that are in Solmin, to their mineral deficient animals. Read Minerals in Soils, Plants & Animals > Cobalt and > Zinc.

The chisel ploughed area on the left of Owen Baker, shows how much better it's clover is compared with the mouldboard ploughed on the right (his left).



Using a PastureGauge© he measured the growth, and his chisel ploughed pasture yields were double those of mouldboard ploughing and of rotary hoeing, and with no bloat. On the mouldboard ploughed paddocks several animals died from bloat. Read Bloat for more on this.



Owen worked in town, and one day his wife phoned him to say the heifers were blowing. He asked her to move them to the next paddock, but she said that it had taller clover, but he replied that it was Vaughan's chisel ploughed area so they won't blow on it.



Chisel ploughs

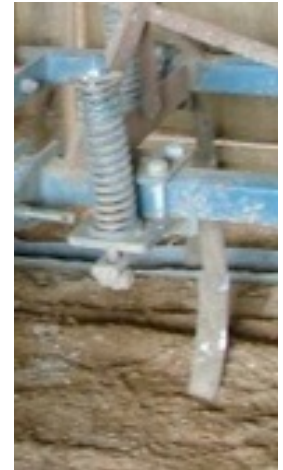
There are many designs of chisel ploughs. I invented and made this

one in 1958, later made by Vogal NZ Ltd. We made and sold 12 on our Piako Road farm near Gordonton just by neighbours seeing our farm from the road. It has been copied by many, however none are now made in New Zealand because of our high exchange rate and low volume of potential sales.

This orange chisel plough below that I made goes deeper than the smaller coil spring ones and is suitable for areas where there are no stumps or stones. Three point linkage at the rear allows it to buckrake stumps into heaps. The two on the right are bad designs because the tynes are too short and the angles are too steep so the soil can't flow up, so are harder to pull.

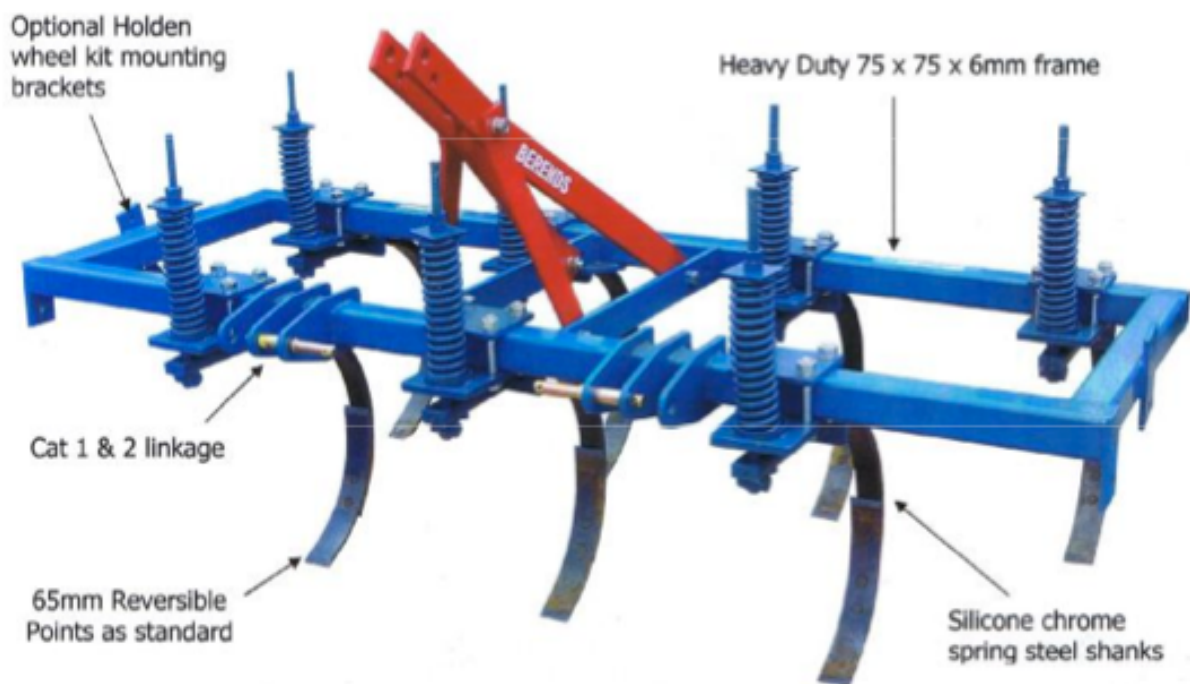


Country Calendar of 12 March 2011 showed Paul Torley, who won the farm of the year in about 1970, that I won in 1959. We both chisel ploughed with coil spring ones like this one.



Coil springs that are soft, so from age, compress, so the tynes lean back and become vertical anchors, which are harder to pull so don't go as deep, nor roll up much subsoil. Springs must be kept tight, not loose as shown on the right. When loose, the tynes drag back and up and don't roll the soil up, making it more like an anchor than a chisel plough, so harder to pull.

This 7 tyne Stump Jump Berends chisel plough below ex Australia from Berends in Auckland is a copy of mine for about \$4,000 depending on size, because Australian exports are subsidised. Ph 09-262-0404, or DavidGock <davidgock@xtra.co.nz> or www.johnberendsimplements.com.au



• Available in 5, 7, 9 and 11 tine sizes with tines at 12" adjustable spacings.

See Berends at Fieldays. Mention GrazingInfo and Vaughan Jones for a discount. They offered me a commission, but I declined and asked them to give the discount to GrazingInfo members to which David agreed, so ask for it. Other brands are from \$10,000 to \$25,000 each.

If the chisel plough has too many tynes for the size tractor and soil hardness, so doesn't go deep enough to bring up enough subsoil to give the soil strength, three shallow chisel ploughings will make the top soil fluffy and powdery as done by rotary hoes. The powdery soil then makes pulling harder and later compaction more difficult, especially if dry. Then the lack of soil structure allows erosion and takes longer to wet. When it does absorb rain, it pugs easily and then sets hard. So avoid destroying the soil

structure.



I like this Kvernland because the tynes only release (tilt back and up) when hitting something, so the tynes remain at the easy to pull correct angle so it goes deeper, but at about \$11,000 is expensive (because it's imported), however some have been bought secondhand from TradeMe or farm machinery dealers. It can have a roller tiller behind to help smoothen and compact the soil, and reduce drying out which loses farmers thousands of dollars in most late dry springs. Chisel ploughing kills almost no earthworms, and achieves the deepening of soils. Earthworms should be fostered to do the same. Read Soils >

Earthworms.

to 40 cm that I and clients did from the 1960s doubled some yields on peat and mineral soils and was publicised in national publications, but was and still is ignored by the ivory tower bureaucrats (establishment) who have no practical experience, and by some farmers who keep doing what their grandfathers did, and by some backward contractors.

Once the clover established and made N and grazing increased the organic matter, the ryegrasses thrived.

In South Africa in 1952 after reading Louis Bromfield's books, and converting to chisel ploughing by removing the mouldboards and pulling just the plough beams through the soil at twice the ploughing depth, we increased the Japanese millet yield by 50%.

After I came to New Zealand in 1954 and bought our first farm in 1955 I designed and made this light seven-tyne spring-loaded chisel plough and many more. My wife Auriel chipped the welds and painted all the implements we made. Twelve farmers on our road (Piako Road, Gordonton, Waikato) saw our farm and contracting results and ordered chisel ploughs that we made in winter. The demand grew so much that we had to get engineering companies, Port Brothers, and then Vogal NZ Ltd, to make them.

Tynes at 65 cm centres on each of two rows as shown, allowed clods, stumps in the peat soil to flow through without blocking. Spring loaded tynes which vibrate when pulled fast through harder soils help break it up. Also, spring loaded tynes are easier to pull in hard conditions and should have even, constant, gradual (not tight) curve on the tynes to allow an easy flow of soil with a high frame, so that the soil can flow up and "bubble" without blockages occurring. The springs should be strong so that tynes don't lean back in hard soils which makes the chisel plough harder to pull and makes it ride out of the soil. Travelling slowly just cuts trenches through the soil as shown here in consolidated peat, without bringing up subsoil and without mixing in the lime, seen here still sitting on top.



All the deep thorough chisel ploughing I've seen done on many soil types have improved them and increased the crop and plant yields, and can increase the bloat-free clover content of pastures which is worth a lot. Read Animal Health > Bloat.

The next two that I designed have no springs because there were no large stumps or large stones, so are cheaper to make and they go deeper. Look at the long shining tynes and the depth. They can be attached to reverse and dig out stumps and buckrake and heap them up.

These below don't have tynes running from the tip (bottom) to the top, so soil doesn't flow up and mix. They are harder to pull and act more like anchors.

Procedure

Keep the time short between starting to cultivate and sowing, so that weed germination will be later

than what is sown. I've seen differences of almost no weeds in turnips and other crops, some sown within two days of starting to cultivate, and 80% weeds in an adjacent turnip crop in the same paddock, where cultivating was spread over two weeks to stagger the sowing for later grazing.

Benefits of chisel ploughing -

1. Cheaper and quicker than other systems of cultivation. Rippers, rip, but don't cultivate, mix soil and lime and fertiliser, and don't make a deeper topsoil.
2. There is little setting up and no operating skills are required, except that when in the soil, the frame must be level both ways.
3. Most of the topsoil is left on top, and most subsoil is left below, except that they are both mixed to the degree required, controlled by the depth and number of times the area is chisel ploughed. Three times is usually ideal.
4. Existing horizontal layers are broken up and cracks are filled, allowing faster moisture movement both up and down.
5. Useful for early spring germination because the warm surface soil is not all turned down and cold soil not all brought up as in mouldboard or disc ploughing, so planting can be done sooner in spring, and done on one day, if the complete cultivation can be finished in that time.
6. Deep chisel ploughing moves lime and reactive phosphate down and brings subsoils up which reduces aluminium toxicity at lower levels in some soils and makes the reactive phosphate more available when it is mixed in with the soil to make contact. Aluminium stops the roots of some plants going down, (especially ryegrasses and some maize varieties) so decreases yields and increases ryegrass pulling. Read Minerals in Soils, Plants & Animals > Aluminium.
7. Deep cultivation brings up minerals in subsoils that clovers need, and animals like. Note the improved clover growth that occurs where subsoil has been brought up, trenches have been dug, etc., showing that there are minerals we don't even know about, but which have been depleted by many years of farming the top 15 cm of soil. Sir Bruce Levy (Grasslands DSIR director) noticed in the 1930's that clovers did better in subsoil, and I have noticed this all round the world. Read Soils > Cultivation. Soil and pasture analyses I've done have failed to explain the reason, showing that we still have much to learn about elements in soils. Dozens of comparative trials I've organised show that clovers do much better in chisel ploughed soils than in mouldboard or disc ploughed soils or just rotary hoed or power harrowed soils. Do a comparative trial on your own farm. When grasses and clovers grow better on the sides of roads and lanes, and animals prefer eating them, it shows how the top 15 cm of soils have been mined and that subsoils and quarry blue metal or gravel, have some goodness, so chisel plough to benefit by bringing up your higher mineral content subsoil. Doing so is more profitable than buying Rok or Humate Type so called fertilisers that are not fertilisers.
8. Some of the fertile topsoil is left on top, which allows seedlings to establish more quickly.
9. Incorporates plenty of warm spring air, mixes the turf and lime in thoroughly, and leaves an aerated crumbly structure.
10. Allows lime to be applied first and be chisel ploughed in, followed by chisel ploughing fertiliser in. Mouldboard ploughing fertiliser and lime in, is not recommended because it is left in a thin layer. With lime and boron mixing in is even more beneficial.
11. Correctly designed and well made spring loaded chisel ploughs outlast other types of ploughs.
12. When soils are wet, it is much easier to continue cultivation after chisel ploughing than after mouldboard ploughing, because there are no furrows, and no sods of turf to slip from under the tractor wheels.
13. Cultivation can be done evenly over the whole paddock right up to fence lines.

Chisel ploughing is like a million earthworms going through a paddock, which encourages subsequent earthworm activity because it doesn't kill any, and gives a more friable, deeper soil with better moisture retention. Soils chiselled deeply retain moisture better than soils cultivated in any other way. Earthworms are then more active in moist soils.



No Till

To my knowledge, no-till promoters have not compared their short term system with chisel ploughing. I don't know of any no-till method being used by farmers for more than three or four years, because soils start failing when aluminium helps cause a hard pan which ryegrass roots don't go through, and the top 15 cm becomes farmed out, and top soils become shallower, so drying out becomes worse than in chisel ploughed soils.

Spade hoes

Spade hoes can be used to advantage on peat, but their very high cost limits them to contractors or very large farms. They can go to 40 cm (16 inches) in peat and make a seedbed in one pass without pulverising wet peat, but they can pulverise dry peat, which then has difficulty absorbing water and compacting. Rotary hoes can skim hoe just a few centimetres deep before chisel ploughing, but kills some earthworms, but is better than using glyphosate, as is Grazon which costs a lot more, but to my knowledge and research is not dangerous. I've used it since 1997. Read Gardens > Lawns.

Subsoil & sand

I did this trial and recommend that all farmers do one or more using their soil in preserving jars, to show the benefits of bringing up some subsoil when chisel ploughing for crops and new pastures - a little like applying rock dust that some farmers buy and spread for up to \$400 per 1,000 kg. They could bring up subsoil much more cheaply for much better results because chisel ploughing brings up much more, mixes it, and deepens and improves the top soil at the same time.



The left jar was all topsoil, the next 25% local subsoil, the next 50% local subsoil and the right one 75% local subsoil, all mixed thoroughly. Each jar had one clover and one ryegrass seed. It shows how clovers need the minerals in subsoils, and ryegrasses need organic matter. Look at the clover roots on the right. I've seen nodules 35 cm (14 inches) deep in correctly limed, chisel ploughed and fertilised soils.

Why buy what are only soils with minute amounts of additives. I've seen Humate equal cost comparative trials giving dreadful results.

The better clover on the edge of a road in Hamilton shows where a trench was dug for telephone cables 25 years before, bringing up subsoil. The trench went along the edge of the road and then right to a house. The topsoil was only a 10 centimetres deep.

I and many others have seen examples of this where clovers have grown better where subsoil has been spread on top when levelling, digging deeply to bury pipes, in gravel on the sides of lanes, roads and in sand quarries shown below. Very little topsoil was replaced over metres deep sand.

When clovers do well, animals and grasses do well, and profits increase.

This right angle turning method of cultivation saves turning 360 degrees, and chisel ploughs the paddock twice. Start at one corner and go at a 45 degree angle to the far side, turn a right angle and go at a 45 degree angle to the first side. If the paddock is a long (rectangular) one, turn a right angle, and keep doing this to the end then work back doing the same thing until all is chisel ploughed twice.

The final chisel ploughing should be round and round, to leave the paddock smoother in the way it will be harvested and fertilised. Some chisel ploughs can have harrows and a roller, so that the third chisel ploughing leaves it ready for one or more rollings before sowing. This saves owning a rotary hoe or power harrow.

This roller cultivator has a ripper (subsoiler) in front. A chisel plough in front would be better.

After chisel ploughing twice, spread the fertiliser. It is important that lime and phosphates are applied and cultivated in separately, because mixing them slows the immediate release of P, but lime helps release fixed P. In dozens of trials cultivating fertiliser in has given far better yields of summer forage crops and pastures. If applied after all cultivation and there is little rain, as is common in late spring and early autumn, the roots will go down into soil where there is no fertiliser, so the plants will grow slowly, while most weeds that don't need fertility will thrive. As well as lower yields, crops will

show drought and deficiency effects earlier.

If you have a tractor with enough power, attach a Cambridge roller packer (USA term) behind the chisel plough at the final chisel ploughing, or all if dry. This will save an operation and give a smoother surface.

Harrows can be fitted between the chisel plough and roller. A 45 kW (60 hp) four wheel drive tractor is being used with a five-tine chisel plough.

Three chisel ploughings take about the same time as one mouldboard, or one disc ploughing.

Dual wheels on the tractor help compact the soil. I've seen better germination and higher yield three years after sowing.

This photo of foot steps and wheel marks show the firmness necessary for adequate compaction, germination and grazing. Note the foreground, how was like before rolling.

The Cambridge roller V's allow seeds to be buried in them to the correct depth. A frequent reason for poor clover germination is burying it too deeply. A branch dragged behind the roller buries the seed perfectly. Don't harrow it in.

To bulk up the seed for an even spread, mix the seed with slightly dampened lime, sand or safe fertiliser that won't burn. Boron, copper, potash and/or superphosphate in fertilisers all burn seed, but if sown straight after mixing into moist soil and buried, burning may not occur. Treating also protects seeds and reduces insect damage, and if legumes are inoculated, N production can be higher, especially if there had been no clover for a while. Broadcasting the seed is best. If drilling pasture seed, it is best to halve the rate and cross drill to get a more even spread, and to prevent the seedlings competing with each other, because some will then die which is a waste of seed and money. Roll thoroughly to pack moist soil around the seed. Cultivating and sowing areas small enough to finish all in one or two days reduces moisture loss and does a better overall job.

Avoid destroying the soil structure by over-cultivating and ending up with a powdery soil, as occurs after repeated rotary hoeing or power-harrowing, which also kill earthworms, lead to a fluffy and then compact soil which restricts water, decreases rainfall absorption and water movement, air and root movement, and makes it dry out more. It takes years for the destroyed soil structure to recover.

If the soil is very wet, chisel ploughing over a period helps dry it out without damaging it.

If you are planting a forage crop don't worry about a few pasture plants surviving. They add to the feed and make the change from pasture to the crop easier on the animals. Read Forage Crops > Maize.

When soils are dry, or likely to get dry, cultivate small areas to be able to start one day and sow the next. Losing moisture ahead of dry periods from prolonged cultivation is losing money.

A major advantage of a short time between starting to cultivate and sowing, is the fact that weed germination will be less and will be slower than whatever is sown. I've seen differences on the same paddock of almost no weeds in turnips sown within two days of starting to chisel plough, and 80% weeds in an adjacent turnip crop in the same paddock, sown two weeks later after further cultivation. It was done to stagger the sowing. If staggered sowing is needed to match the grazing, stagger the cultivation by not starting until the day before the sowing day.

Over cultivation can be so bad that pastures end up worse after than they were before, and/or they don't last. Mouldboard ploughing and especially rotary hoeing are the worst at creating problems and short-lived pastures.

Chisel ploughing releases nitrogen, so don't apply any N until crops or pastures show signs of needing it. If you do, you could be wasting your money on the N and cause your animals grazing the crop or pasture to get nitrate toxicity. Read Animal Health > Nitrates.

Chisel ploughing correctly brings up subsoil and mixes it in with the topsoil, so improves and deepens the top soils, neither of which can be achieved with no-till.

The long-term benefits of chisel ploughing which can double the depth of top soils include -



1. Less pugging because hard pans reduce water movement downwards so become wetter and pug.
2. Healthier soils, soil microbes, earthworms and animals.
3. Less drying out.
4. Much higher yields of crops and pastures, especially maize and clovers. See photo below.
5. Bringing up minerals that we don't even know about, but in the words of organic farmers 'remineralise' soils that have been depleted of them for more than a hundred years in New Zealand, and for many centuries in some countries. The dust bowl that ruined parts of central USA was partly from their 'mining' of the top 15 cm. Louis Bromfield wrote about it in his book *Malabar Farm*. See Further Reading. Google to buy one.
6. Fewer weeds, because healthy productive deep soils grow better pastures and crops, while poor shallow soils grow more weeds.
7. If you sell the crops off your farm, you can end up with dust bowl, which Louis Bromfield fixed on the four dustbowl farms he bought by chisel ploughing, growing and grazing pasture, and using other good farming practices, which resulted in his farm becoming the current heritage-farm in Ohio which attracts thousands of visitors every year.
8. Make more profit.
9. Chisel ploughing can pull up for removal, large stones, tree stumps and roots. They grow nothing, so waste soils space. Small stones can be different. Where these were removed from soils, they yielded less.

In peat soils, some complain about the number of stumps that chisel ploughs bring up, but nothing will grow on stumps, so the sooner they are removed the better.

Cultivation by chisel ploughing deeply, brings up valuable subsoil, creates deeper topsoils which build and hold more humus, allows deeper plant roots, and grows higher yielding plants, with the bonus of reduced leaching of elements into underground water because the deeper plant roots are able to access more nutrients before they leach to below the root level.

If you don't bring up subsoil you won't get the clover growth and mineral advantages shown below. The subsoils I've measured have more salt and magnesium. MAF trials near Reporoa, NZ, feeding salt gave 15% more milk production.

The heading "Cultivation" should really be "Chisel ploughing" because it is mostly better than other forms of cultivation as will be explained. Dozens of comparative trials in many soil types that I've done since 1952 or organised around the world, have always shown that chisel ploughing improves soil depth and structure, and gives higher yields of crops and pastures with more earthworms than other types of cultivation.

This doesn't apply in pure pumice or pure sand, or in soils with only a few cm of topsoil, in which case chisel ploughing should not be deeper than twice the depth of the topsoil, because doing so would dilute the topsoil and reduce the organic matter too much.

Much of this chapter is aimed at increasing pasture and crop yields and extending the grazing periods, both of which are much cheaper than mechanical harvesting and feeding. Read *Forage Crops* for a photo of 1.5 metre high kale ready for grazing in winter in Canada, and 60 cm high Pasja and Nutrifeed growing of high producing forage every 18 days even in dry conditions.

To justify the cost of cultivation and growing forage crops, the yields must be high.

The aim with pasture improvement should be to end up with a pasture that will last for a long time, except for drilling in or oversowing pugged areas and to bring in new improved species, as and when it is profitable to do so. To achieve long lasting pastures, thorough and deep cultivation with adequate lime and correct fertiliser must be done at the time of establishing them.

Cultivation is usually to prepare a seedbed for sowing crops or pastures. The most important things to achieve are to bring up subsoil for its minerals, and mix it with the top soil to deepen it, to shape and smoothen the surface and end up with a firm seedbed so that seeds are not buried too deeply - a frequent cause of poor germination. Many seeds, such as clovers and most grasses, have to be within a centimetre (less than half an inch) of the surface to come through. A good standard is for seeds to be buried three times the depth of their diameter for large seeds and four times for small ones.

Before deciding on cultivating and re-grassing, check why it is necessary, what caused the need, and what has to be done to ensure that the pasture doesn't deteriorate again. If the cause is a lack of

fertiliser or lime, apply it before going to the expense of cultivation in case cultivation isn't necessary once mineral levels are optimised. Read Minerals in Soils, Plants & Animals > Calcium.

Preparation

Like grazing systems, there is not one form of improvement that applies to all areas.

If the whole paddock is wet, then spinner drains, called ditches in some countries, may be necessary. In NZ, ditches are those carrying irrigation water. Spinner drains should be installed every 30 metres in very wet soft peat bog and heavy wet clay, or as required. A grader blade on an acute angle can also dig a shallow drain. Then drag the soil to hollows. Read Soils > Draining.

Cultivation and resowing are expensive, so wherever possible use animals to improve pastures by mob-stocking and feeding hay and/or silage on them. If growing a crop, use animals to cultivate the surface before chisel ploughing. Carrying out the following can destroy the turf before chisel ploughing, saving having to spray or rotary hoe. Another advantage of using hooves is that they can kill slugs, Argentine stem weevil, springtails, black beetles and other pests which might otherwise damage the seedlings of crops and pastures.

Correctly managed pastures (limed, fertilised, have earthworms, deep rooting Red clover, lucerne, chicory, plantain and good drainage), in many areas can thrive without chisel ploughing, and can continue to improve, but won't be as good as when new varieties of grasses and clovers are sown in soils which have been deepened through chisel ploughing, by bringing up the minerals in subsoils that benefit legumes in particular, and surface living earthworms to a degree.

Maintaining old pastures without resowing is necessary on steep hills, stony soils and vast areas of natural grasslands where chisel ploughing and resowing are impossible or not profitable. In some of these areas oversowing and/or drilling can pay, especially where suitable improved species can be incorporated. However, land that has been in pastures for decades and is expensive or limited (no more land available to develop), can give profitable returns from cultivating properly, liming if necessary, and being re-grassed with the latest higher producing pasture species. Emphasis is on the word 'correctly', because poor results and even complete failures can occur, which encourages some to use these failures as an excuse for not cultivating to improve soils and pastures.

Some may ask, "Why grow pasture at all if crops are so good and can yield so much?". It is because good pasture costs less to grow and feed, is a better quality and more complete long term feed for ruminants, less susceptible to droughts (dry weather for a month after sowing a crop can be disastrous), floods, hail, weeds and pests. Also, crops need pasture for grazing with crops, or to be fed as silage or hay with crops. Pasture is also much kinder to the environment than cropping.

When to cultivate

Chisel ploughing deeply and sowing the latest and best grass varieties that have insect resistance, and clovers that yield more and produce more nitrogen, and herbs suited to your areas such as Tonic plantain, can be profitable. Check with all the seed suppliers, neighbours and successful farmers in your area to get the names of the most suitable ones for your farm. Some perennial ryegrasses have been developed for the North Island and different ones for the South Island.

If a paddock is rough (uneven), or producing less than others, but has been equally limed and fertilised, and perhaps animals don't like the pasture and break out to eat pasture on the roadside, then it may improve from chisel ploughing to bring up minerals in subsoils. Over-fertilising with artificial nitrogen, too much K, as well as inadequate lime and trace elements, cause cattle to reject pasture, eat less and produce less.

Shallow cultivation can damage the soil structure, especially if dry, but if you have to, then cultivate only as much as you can do and sow in one day. Cultivation and sowing within a day or two reduces moisture loss. Also humus and soil organisms are not burnt up by the sun, and weed seeds are not given a start on the crop or pasture.

Contractors who have big gear, and don't have to milk or do other daily farm chores, can usually achieve this. If not, then do a smaller area so that it can be achieved.

In wet soils and conditions, time may be used to help dry it out, but optimum drainage with ample shallow spinner drains is the best.

Some weed seeds germinate after being exposed to light. To reduce weeds in crops, some organic growers in Germany cultivate at night without a rear light on the tractor, or during the day with the

cultivation equipment covered with black plastic sheets to prevent light getting to the soil. A chisel plough is easy to cover.

Much of New Zealand is steep hills in grazing pastures that get like this on the left. The smooth right was like the left before cultivating and shaping it with a crawler tractor working straight up and down. Today's 100 plus kilowatt four wheel drive tractors can do the same and faster.

Weed elimination

Paddocks are sometimes cultivated to get rid of weeds. Earthworms eat organic matter in soils, which includes weed seeds. Lime and its synergisms increase earthworm numbers more than anything else. For masses of healthy earthworms, all elements must be present at optimum levels, based on



the leaf analyses of pastures, crops or fruit trees. Read Minerals in Soils > Calcium. I've achieved and seen farmers eliminate weeds following correct rates of lime and fertilisers, which is a lot cheaper than cultivation, but cultivation with a chisel plough does bring up subsoil with all its benefits of better clover, so better pasture.

To get rid of thick weeds (this doesn't work on Couch and Twitch), trample or rotary hoe, chisel plough, then sow and graze a forage crop. Then sow and graze another forage crop, then sow new pasture in autumn or in spring in the Northern Hemisphere snow covered areas.

Weeds prefer acid, low fertility soils, while forage crops and pastures like high fertility, so apply the required amount of lime and fertiliser each time and then 3,000 kg of lime per hectare (2,700 lb per acre) on the surface, and harrow it in before sowing the pasture. If you forget, applying it on top even after the grass is up. The top part of soils need to have more lime. Doing this increases earthworm activity, most of which live and work near the surface on animal manure and dead vegetation, reduces facial eczema spores, and some weeds.

Some weeds prefer wet, sour conditions, so reduce them with the correct amount of lime-plus. See Minerals in Soils, Plants & Animals > Calcium, the application of which has 50 benefits, one of which is making soil softer so easier to cultivate.

Base the lime and Mg application rates on the tissue levels of the pasture or crop, not on the pH because it is highly inaccurate. See Soils > pH & Lime requirements.

If the earthworms have little lumps of soil stuck to their body, more lime is needed. See Soils > Earthworms. What you see in the soil is worth more than what soil tests tell you. Correct pasture analyses usually back up what one sees.

After chisel ploughing in lime, more must be applied on the surface and harrowed or roller cultivated in, or the top few cm will be too acid for legumes and earthworms, and too low to discourage acid loving weeds such as rushes, Pennyroyal, Chickweed, and others such as Buttercup to a lesser degree. See Pasture > Weeds for more information.

Lime increases earthworm numbers more than anything else, but all elements must be present at optimum levels, based on pasture, crop or tree leaf analyses. Urea reduces earthworm numbers.

The high cost of regrassing is in the pasture seed, so before sowing the seed, grow two forage crops to encourage weed germination and bring up subsoil which is full of minerals like rock dust which organic farmers buy at quite a high price, when all they need to do is to bring up their sub soil with a chisel plough.

To sum up this part of weed control, don't boom spray and don't allow weeds to seed. Harvesting weedy areas and paddocks for silage, and mowing before grazing, reduces them. See Pastures > Weeds.

Subsoiling

Most farmers know what subsoiling is. Some call it ripping. Many don't know that having to do it shows that their farming has been at fault, mostly through a lack of LimeMagPlus and earthworms,

however, soils with iron stone layers are harder and slower to fix, and benefit from subsoiling.

Subsoilers consist of a frame, to hold between one and seven shanks up to 60 cm long, sometimes with coulters which cut the turf to reduce soil disturbance, without which weeds can grow in the encourages weed germination. The shanks usually have 5 cm (2 inches) to 40 cm (16 inches) wide tips at the bottom, and are pulled by tractors, on the contour, if on sloping soils.

They can have shear bolts which shear if a stump or stone is hit, but speed should be much slower in these conditions.

Correct subsoiling increases the soils' structure and pore space in some soils, and giving better moisture movement in some dry soils. It also allows oxygen to enter soils and gases to escape.

Power required in hard soils is about 20 kW (27 hp) per shank.

This peat farmer owned a James subsoiler and as shown was not getting results because of the narrow 5 cm pointed tynes. I lent him my 40 cm (16 inch) wide three tyned Vogal subsoiler and then visited him to compare the results.

On some soils such as Hamilton clay loam (a shallow, old New Zealand volcanic, hard clay with a hard subsoil), subsoiling of any kind gives absolutely no benefit, and can even be negative by creating cracks that grow weeds. Know your soil and what it responds to, and if necessary do small trials with a borrowed or hired subsoiler. There are many subsoilers lying unused, especially those with 5 cm wide tips. See Sources at the end.

Five cm wide short tips at the bottom of tynes don't do much, while 5 cm by 20 cm (16 inches) long tynes lift and aerate the soil as shown in the bottom photo.

The power-take-off driven Shakaerator (TM) subsoiler made by Yeoman in Australia increases the tip's shattering effect, gives deeper penetration of hard soils and makes pulling easier. Try one or ask an owner. When I demonstrated one in hard soil on the field days Mystery Creel property, the tractor ground to a halt each time the power-take-off was disengaged. It is a very strong machine made for hard dry conditions.

Subsoiling can improve drainage and in some cases make puddles of water disappear in minutes.

They can have optional extras and mole ploughs to drain large wet soils, but this has to be repeated every few years depending on the soil type.

I invented the Vogal 40 cm (16 inches) wide tips Toolbar in 1964 that aerated wider areas and had thin sharp shanks for ease of pulling and minimum pasture surface damage.

No-till

Unfortunately some people with vested interests (selling drills, etc.) write as if no-till is always better than any cultivation system. If they compared no-till against chisel ploughing deeply to bring up minerals rather than against rotary hoeing or other shallow cultivation methods, chisel ploughing would give far better results.

Many farmers who have tried no-till cropping get lower yields after a few years then try subsoiling and after a few years often go back to proper cultivation with a chisel plough. On peat and pumice soils drilling gives only half the yield, especially when lime is needed to be chisel ploughed in deeply.

When cultivating before sowing forage crops (maize, millets, brassicas, etc.) and pastures, chisel ploughing is essential. In some stony soils cultivation is impossible, but there are some stony soils that can be chisel ploughed lightly. If, however, all it does is bring up more stones without the benefit of bringing up subsoil, deepening the topsoil and mixing in lime, then fostering earthworms, including *Terrestris*, is even more important. See Soils > Earthworms.

In these stony soils it is more important than ever to farm with the aim of improving and deepening soils. This is done by having perfect drainage, applying LimeMagPlus, if needed based on pasture analyses, not useless soil tests which don't tell a full story about anything, applying the best reactive



phosphate (if the soil is acid) rather than Superphosphate which makes soils more acid (see Fertilisers) with fine elemental sulphur (if needed). Sow pasture and then do pasture leaf test (see Pastures) and apply the necessary elements, and bring in *Terrestris*, *Calignosa* and *Longa* earthworms to help improve and deepen the top soil. See Soils > Earthworms.

Proper cultivation with a chisel plough usually costs little more than spraying or no-till, and gives much better long-term results in all soil types with which I've been involved in all of New Zealand and many other countries. All other things being equal, no-till (spraying) re-grassing of run out pasture, on run out soils, usually gives a new pasture life of about three years, rotary hoeing about five, ploughing about ten years and chiselling deeply, about twenty or more years and in all those years the chisel ploughed will usually out yield the others and give healthier soils, pastures and animals.

No-till doesn't kill insects, but correct farming by using the paddock to be chisel ploughed as a sacrifice one by thorough trampling, followed by chisel ploughing does, and it saves damaging other paddocks.

Using no-till on New Zealand's 260,000 ha of farmed peat would be an even disaster and would not deepen topsoils on it or on sandy pumice soils.

In most cases subsoiling is trying to imitate mechanically what earthworms do naturally, provided conditions are right for them, which is rare today because of urea, hormone weed spraying, and mainly insufficient agricultural lime, and other deficient elements shown by pasture analyses.

Earthworms which increase after applying optimum rates of LimeMagPlus can do a good job aerating tight soils that have suffered from years of bad farming of repeated grazing too short, insufficient LimeMagPlus and using incorrect fertilisers, usually because of not using pasture analyses. These get rid of hard pans and iron layers and allow moisture to move down and up again. Earthworms can correct most, but can't correct the problems of ironstone layers, unless done for decades with the help of LimeMagPlus and bringing in the best three earthworms.

Dr John Baker, ex Massey University, is president of the No-Tillage Association, and Dr Craig Ross is a Landcare Research scientist. They wrote on 7th May 2008, "There are numerous examples around the world of land laid barren by continuous tillage."

I add, "With mouldboard ploughing, wrong fertilising and mining by removing everything grown, until the organic matter levels decrease and the soil becomes sand. Chisel ploughing and grazing pastures or crops reverse this."

Dr John Baker & Dr Craig Ross lost all their credibility, because they were over-promoting their incredibly expensive no-till process that mines the surfaces of soils and fails after a few years, 'so farmers revert to cultivation after three or four years' - John Baker's words.

"The trouble is we already know of New Zealand farmers who have started ploughing again, undoing the several years of soil health improvement they had already achieved with no-tillage."

Because farmers are not fools, except when they adopt unproven practises such as no-till, buy subsoils (Rok, humates, etc.), when chisel ploughing brings up subsoils often better than what they buy, and a lot less costly. When Rok suppliers are asked where it comes from, they tell northern farmers, from the south, and southern farmers, from the north!

No-till sales people also wrote, "No-tillage often takes place without any chemicals at all, such as following harvests of grain crops. In any case, the single most commonly used chemical in no-tillage when weed control is required is Roundup, the most environmentally friendly agricultural chemical that has been ever invented. It is less toxic than table salt or sugar. It was first developed as a detergent. If Roundup is nasty, then so too are all detergents."

Google for 'Roundup human sicknesses' and 56,000,000 (they can't all be wrong) will come up showing that it adversely affects DNA, soil microbes, triggers over 40 plant diseases, in womb unborns, can cause Parkinson's disease, etc., etc.

More tripe - Dr Arden Anderson asserted in Rural News (1 April 2008). "No-Tillage does not lead to depletion in the top soil of essential minerals for plant growth and depletion of soil carbon. Quite the reverse. It is conventional tillage that does that. No-tillage reverses the process."

What farmers do is the proof, not what sales people say

Because farmers experienced the problems of the top 15 cm of soil being mined and running out of minerals that are in subsoils, which chisel ploughing brings up.

Google for "Glyphosate banned" which is the generic name for Roundup, and you'll see that most

of the above by Baker and Ross is utter tripe, and some is typical plain wrong sales talk.

A townie neighbour has since died, partly because he used Roundup, and partly because the Hamilton City Council spraying along gutters in front of his home. I have forbidden them spraying within 30 metres of our home. Australia has banned spraying waterways, which gutters are.

About 10% of people are severely allergic to Glyphosates. Some countries have banned it completely because as in Australia, it is polluting subterranean water.

Monsanto and no-drill people write that Glyphosate becomes harmless once it is in the soil, but this is wrong because it can build up in underground water, as has been recorded in Australia. Google for Roundup + Cancer to see 1,600,000 pages on it, and it will help you become more determined to farm without it and some other sprays.

In Baker's case the earthworm count is deceptive because loosening soil in any way makes earthworms go deeper because their enemies are birds, hedgehogs and rodents, all of which loosen the soil, so earthworms go down. In doing so they make soils deeper, and bring up subsoil.

A fair comparison would be trials comparing it with chisel ploughing and like I did with broad beans shown here and in the Gardens Chapter.

See Gardens > Broad beans in our garden. All got agricultural lime at 0.6 kg per m² (6,000 kg per hectare) and fertiliser described below at 0.1 kg per m², (1,000 kg per hectare) and 10 cm of compost dug in 40 cm deep. The left metre was "no till" so everything was applied to the surface. The metre on the right got Tri-Fix equal to two litres per hectare. They had thicker stronger stems and no rust and yielded 8 times more beans than no-till.



No-till has been promoted a lot by those recommending alternative and biological farming to make them sound good and to get attendance at their meetings and publicity, but after a few years farmers have to subsoil and later go back to proper cultivation which is best done by chisel ploughing. Many have done comparative trials between chisel ploughing and mouldboard ploughing, and never go back to the old fashioned inverting soil.

No-till is promoted in New Zealand mostly by commercial companies manufacturing unbelievably massive machines that only contractors can afford, and give no real long term benefits.

Chisel ploughing and No-till in USA

Jim Snyder, NRCS District Conservationist, Edmore, Michigan, USA answered my question in 2008.

"My experience with chisel ploughing goes back about 30 years. It is a very popular practice on the tight clay, glacial soils in this area of Michigan and further south in Ohio.

"Mouldboards went out in the 1980's when chisel ploughs became popular, so most farmers use chisel ploughing on a regular basis to reduce subsurface compaction, from getting on the soil with heavy equipment to cultivate or spread liquid manure when it is too wet.

"If the soil is erodible, there are compliance issues with farmers who participate in USDA farm programs. They are required to leave a certain amount of crop residue on the soil surface.

"Deep chisel ploughing is common every few years, even on some no-tilled soils. Unfortunately, it takes a lot of power and fuel to do it properly. A chisel plough with long shanks can go down to 40 cm (16 inches) which breaks up subsurface compaction and plough pans".

Many soils that have never been ploughed have so-called hard pans simply caused by high aluminium and low calcium levels, easily fixed by chisel ploughing LimeMagPlus to full cultivation depth, which discing and mouldboard ploughing, can't fix.

If soil tests show a need for lime, add it before your last tillage operation. The tillage will distribute the lime throughout the plough layer. After starting a no-till system lime applied on the surface will take years to move down. Optimal New Zealand shallow soil pH measured levels can be maintained by surface applications of liming materials, but, healthy deeply cultivated soils will need more lime.

The surface of the field needs to be fairly smooth. Ruts and other uneven surfaces should be tilled out. Planting into an uneven surface results in varying seed depth and an uneven stand.

Malabar Farm

Louis Bromfield bought four dust-bowl run-down farms in Ohio, USA, in the late 1940's. The dust-bowls from the 1930s, and still occurring on a small scale in USA and in Australia, were partly caused by repeated mouldboard ploughing, and other bad practises such as selling harvested crops off the land for decades without returning organic matter as is done by grazing animals. Bromfield changed the 150 ha of eroded, weedy, dried up springs, to grazing green pastures to return animal manure and organic matter instead of harvesting and removing it. Clean streams and sustainable farming, partly by chisel ploughing that brings up subsoil and strengthens the top soil. His model Malabar Farm is now State run Heritage farm, attracting 200,000 visitors a year.

Reading his books in 1952 helped me improve my parents 100 ha mixed farm that I was managing in Natal, South Africa where I was born, and then to improve the undeveloped, over-drained 40 ha peat farm that I bought in New Zealand in 1955. See details of Louis Bromfield's books in Further Reading.

There are many benefits of chisel ploughing, but some people love mouldboard ploughing and hoeing, to the detriment of their soils and their bank balance. Wind and water erosion after these cultivation systems can be excessive, whereas chiselling leaves some debris on the surface so erosion is usually minimal. In parts of USA this is now a requirement. Google for "Dust bowl USA" or see -

http://images.google.co.nz/images?q=dust+bowl&oe=utf-8&rls=org.mozilla:en-US:sofficial&client=firefox-a&um=1&ie=UTF-8&ei=bm8bS5vXA526tQOmydyzBA&sa=X&oi=image_result_group&ct=title&resnum=4&ved=0CCEQsAQwAw



In 1943, Edward Faulkner of Oklahoma, USA, in his book Plowman's Folly, wrote about the many disadvantages of mouldboard ploughing. What he wrote has continued



to be true on many farms in many countries, and yet farmers still mouldboard plough or worse still, rotary hoe.

Those who use the old fashioned mouldboard ploughs continue mining the soils to that depth, and zero tilling is worse because it discourages the mixing in deeply of lime and deep rooting. Some mess around with fallows for several days, weeks or longer before sowing, causing weeds to germinate ahead of the crop or pasture seeds, which grow slowly in the turned-up cold subsoil.

Cultivating equipment

If you are against all sprays, and there are no troublesome weeds such as couch or twitch, use your animals to trample the turf, and/or chip hoe or power harrow once only and deep enough to cut into the lowest hollows, then chisel plough. Use the paddocks to be cropped as sacrifice paddocks in wet weather to reduce pasture damage of good pasture. The mob stocking on the paddocks to be cropped also kills slugs and many insects.

If spraying, decide whether at the same time to control insects such as slugs, cutworms, Argentine stem weevils, etc., by animal treading to avoid toxic sprays.

Deep, fertile soils do well whatever cultivation system is used, but shallow poor ones grow much better crops and pasture if chisel ploughed, which keeps most of the fertility on top and still deepens the top soil by bringing up some subsoil.

One problem is that some farmers love to watch a mouldboard plough turning the soil. However, chisel ploughs are better at achieving the best results. Mouldboard ploughing can leave ridges, empty furrows, layers of turf and lime and hard pans. A layer of vegetation turned down can make gases that have difficulty escaping from a ploughed soil.

Another reason some favour mouldboard ploughing is to bury trash and stubble, but as shown below chisel ploughs can do it even to grain-harvested and then control grazed maize stalks.

Cows on typical high nitrate pastures will enjoy grazing maize stubble low in preparation for chisel ploughing. For full details see Forage Crops > Maize.

On small and even medium size farms, it is often better and cheaper to use contractors to cultivate and sow crops and pastures, but if doing so, book them up to a year ahead for specific dates. If they don't adhere to them, change contractors or get your own gear in conjunction with neighbours to reduce capital costs. When contractors arrive, check that their chisel plough is set correctly and that they go deep enough and fast enough to mix the soil, and that they don't have weeds or weed seeds stuck to them.

Lost production from late crop and late pasture sowing can cost a lot. Failures abound with each blaming the other. It helps to give your contractor written instructions as set out below. I'm not criticising contractors, I was one for seven years, doing mowing, lacerating hay and silage, and breaking in hundreds of hectares of raw peat from scrub and rushes - with one rotary hoe cut, followed by three chisel ploughings. I was not late, because I didn't over commit, I drained clients land correctly, could keep chisel ploughing in wet conditions and had access to extra drivers (one was my wife Auriel) to go all night.

At the Indiana, USA, 1990 show, there were only four mouldboard ploughs, but dozens of chisel ploughs, showing the swing away from mouldboard ploughing to conservation tillage, which leaves trash on top. Also, smaller tractors can be used, using less fuel per hectare.

Some use rotary hoes and power harrows, which as little as once over on some soils, or if over-used on any soil, kill earthworms and destroy the soil structure. The soil then packs down too tightly and doesn't let water or air in.

Have the right number of chisel tynes for the size of the tractor, so that adequate depth is achieved while pulling it at about 8 km per hour to bring up subsoil and mix it. Generally 9 kW (12 hp) is required per tyne on a well designed chisel plough and tractor with duals. If this can't be achieved, remove two tynes.

Instructions to print for staff or contractors

Copy and paste the following to a blank page and delete the imperial or the metrics, then copy and paste it four times on to one blank page to copy and cut into four. It will save you time explaining to staff or contractors every time, and will avoid mistakes.

“Cultivating instructions

Pull metres feet off drain banks and spread soil in hollows, around gateways and water troughs, spread lime at kg/ha lbs/acre over hectares acres, chisel plough cm inches deep or to bring up cm inches of subsoil, spread fertiliser, chisel plough twice more in different directions, the last time round and round the paddock, spread kg/ha lb/a of a fertiliser mix travelling at metre feet centres, roller cultivate once, drag leveller round and round once twice then sow, roll once twice if dry. Doing the last operations round and round gives a smoother result for fertilising, mowing, etc., in the future.”

Carbon sequestering

There is more carbon in the world's soils than in all the vegetation including trees.

Move carbon dioxide from the air into plants, roots and soil by growing plants. Carbon is considered moved if it ends up in a stable form, such as in wood or humus in soil. Increasing organic matter in soils, as happens under good management, stores more carbon, especially with organic grazing where no urea is used, because urea burns up organic matter and halves earthworm numbers after each application. The more earthworms, the more organic matter is moved in the soil.

The longer the cultivation takes, the greater the loss of carbon, which is another reason why chisel ploughing is so good. It is fast and allows sowing within a day or two, which also conserves moisture and reduces weed germination without old-fashioned lengthy fallowing. Chisel ploughing doesn't turn down the top warm soil, which is needed on top for early planting in spring.

Chisel ploughing brings up a little subsoil, so deepens the top soil which gives more capacity for carbon and moisture retention, deeper roots and reduces drought effects. The rough surface reduces wind erosion. See the photos of our farm and the neighbours in the Author chapter.

Sources of various chisel ploughs in New Zealand

Berends, Auckland, New Zealand. Made in Australia. Brinks Devlin 09-262-0404. Their prices are half the New Zealand made ones because Australia www.johnberendsimplements.com.au subsidises exports (2011).

Origin Agroup David and Kaye Donnelly, Hautapu Rd, Cambridge, New Zealand. Ph 07-823-7582 info@originagroup.co.nz

Waikato Tractors Ltd, Kahikatea Drive, Hamilton. Ph 07-843-7237.

Also check your local dealers and the Yellow Pages.

Vaughan Jones, ONZM Queen's Honour 2013, for services to the farming industry. NZ M.Mkt.I. Dairying 99% Honours Award 1948. Waikato Most Improved Dairy Farm Award 1959. International Agricultural Consultant & Journalist. Represented NZ in Agricultural Journalist Congresses in USA in 1992 & Austria 1994. Managing Director of the website [GrazingInfo Ltd](http://GrazingInfo.com), compiled since 1970.