Analysing Leaves Versus Soils Version 2.9 19 October 2014

This topic is an important one for farmers and 'old school' scientists to learn from.

The NZ Department of Agriculture wrote years ago, "Leaf tests are needed to give trace element figures, and to confirm that plants are accessing the fertilisers that have been applied."

I ask, "Why do they waste farmers' time and money on soil tests?"

In 1935 pasture mineral analysing was being done in the UK to measure cobalt (Co) levels. A lack of Co in their low organic matter sandy soils caused Pine Disease in their sheep, called Bush Sickness in NZ ruminants a long time after that, and caused the death of 500 cattle in Japan in 2008 on Hokkaido Island's pumice soils.

Co levels are increasing in NZ today after applying urea and superphosphate, both of which acidify (and poison) soils, increase the availability of heavy metals and make animals unhealthy. Read Elements > Calcium, Phosphorus and Cobalt, and Milk Profit & Quality to see the recorded figures. Young growing animals in many countries grow more slowly because of low Co. Pasture Mineral Analyses give the exact Co figures which can then be corrected by applying Cobalt at 1 kg per hectare per annum, until organic matter increases and holds it.

Vitamin B12 deficiency, caused by low Co, has become worse in animals on many farms in NZ that are having to inject B12, because of applying urea repeatedly which burns up the organic matter content in soils, unless LimeMagPlus is applied to increase organic matter and earthworms. Clovers then increase, making artificial nitrogen unnecessary. LimeMagPlus is agricultural lime with serpentine that contains magnesium silicate and all the deficient elements that pasture plant analysing reveal, but soil analyses can't.

Since urea was launched, I've monitored many comparisons on many paddocks and found that urea, at typical rates, halves earthworm numbers. The owner of the urea plant will refute this, in which case they have not done trials, or did on soils they have fertilised excessively with urea and water soluble P and K, so have very few earthworms per spade spit (half of 2, 3 or 4 are not readable, while our best clients have up to 40.)

Sulphate of ammonia is much cheaper than urea and at the same cost per hectare, grows more pasture (with clovers thanks to the S) than urea, and over a longer time.

Healthy ryegrass and clover roots like these on the right in healthy soils fed LimeMagPlus and Gafsa go deep. Clover nodules here at 35 cm went horizontally at the chisel ploughed and limed depth. This clover root depth is never achieved in soils getting superphosphate or junk fertilisers.

This Bealey NEA2 ryegrass, chicory, plantain and clover paddock of Walton clients had 8,000 kg per hectare of LimeMagPlus over three years and was chisel ploughed to 35 cm before sowing a summer forage crop and then the above pasture mix. Three years before this the whole farm had ryegrass roots growing horizontally at about 12 cm because of low calcium and high aluminium, that the ryegrass analysing showed was high, so the ryegrass pulled out. As on many farms, black beetle

was blamed when there were **none**. The farm had received only a total of a 'few tonnes' of lime per hectare over the last 50 years because the pH was 6 and higher, and pastures had not been plant analysed, because of fertiliser consultants getting $12 a tonne commission and fertiliser companies not selling lime. The pasture analysis revealed the low calcium level of 0.38%. It should have been 0.8%.

A farmer emailed GrazingInfo, "I went to a lot of trouble to make sure that the pasture sample I sent to Hills, was ryegrass stem and leaf so the result was useful. In the past when fertiliser company reps and liquid fertiliser salesmen have done pasture samples they have just grabbed a few handfuls of clovers and grasses and the calcium has always been in the mid to high 80s. This backs up what you say about how important it is to analyse one species only.

"I enjoy reading your chapters as you write in a easy to read and easy to understand honest way.

"The Pasture Mineral Analysis, Phosphorus and Lime Nutrient Planners (three spreadsheets) help decide the required levels and the amounts of all elements to apply."

End

Any farmer can use the Lime Nutrient Planner spreadsheet and order from a lime company that mixes good finely ground, preferably soft lime, serpentine (explained in Minerals in Soils > Magnesium) and the deficient minerals shown in grass mineral analyses. Soil Analyses don't show them, because they can't measure some essential minerals accurately, and some soil figures vary with density. Because they are dried and then go by percentage of weight, light soils (peat and high organic matter) show higher levels than clay soils (heavy). Organic farmers who increase their humus levels and use soil tests, are deceived by the increased figures.

Researchers in the Edinburgh and East of Scotland College of Agriculture, wrote, "Measuring and correcting the levels of all minerals in the plants of pasture and other plants, gives optimum plant and animal health and growth, which are essential."

The only accurate way to measure them all is in their leaves, backed by a spade to reveal the health of soils, root depth and earthworms. Read Soils and Earthworms.

Dr Ken J. McNaught, a top Ruakura scientist, in the late 1950's showed that pasture analyses were much more accurate and more useful than soil tests.

Winchmore Irrigation Research Station did comparative trials and showed that pasture analyses were more accurate than analysing soils.

Hill Laboratories wrote, "Leaf analysis provides a more accurate and reliable assessment of the nutrient status of the kiwifruit plant than does soil testing."

Pasture plants gives a complete picture from several weeks growth, while soil analyses give only a snapshot on that day of the soil to 7.5 cm deep in NZ, but 20 cm or deeper in more advanced countries. NZ laboratories, some consultants and so called soil scientists have been changing and arguing over many aspects of soil testing systems for decades, and using more than one measuring system to try to overcome the inadequacy of soil tests.

'Overseer' uses soil testing only, so doesn't show the most important figures that are so necessary for healthy plants and animals, and Overseer doesn't show nitrogen which is the major polluter and cause of nitrate poisoning. Soil samples done after grazing can include urine patches that have high N and K without the farmer knowing it. Pasture urine patches can be seen and should be avoided.

Some soil scientists, who should not be scientists, claim that a soil test can do as well as pasture measuring, which shows their complete ignorance. Ken J. McNaught, a top Ruakura scientist, in the late 1950's showed that pasture analyses were much more accurate and more useful than soil tests. The Winchmore Irrigation Research Centre, I and many others agree. Most of the clients I get are ones who have failed after using soil tests.

After you get a pasture plant analysis you'll see how simple they are to read and use, which soil analyses are not.

I get many phone calls asking to help deciphering soil tests. I decline for many obvious reasons and encourage a pasture analysis.

Pasture & soil levels compared

Comparative figures from Winchmore Irrigation Research Station show herbage figures are more accurate. Their comparisons showed that soil P levels take up to three years to increase and longer to drop again after P application stops, whereas herbage levels increase and decrease within months, so are again a more accurate guide.

At Winchmore Irrigation Research Station in South Canterbury on stony silt soils, measuring perennial ryegrass and clover pastures, the plant figures changed gradually as expected, while the soil test figures moved up and down for no reason and took a long time to change after fertilising. Some supporters of soil tests will say that they are just guides and that the optimum range is between an Olsen P of 15 to 30. This is ridiculous because it is a 100% variation and I know that in some cases 20 indicates low P levels, and 30 high, although many of New Zealand's high producing pastures are over 45. At this stage it should be repeated that the Olsen P system was developed for alkali soils in USA. 99% of New Zealand soils are acid.

Similar annual fertiliser was applied and pasture and soil Ca, P and K levels were measured. Pasture leaf levels were fairly consistent while the soil ones were not. Sampling was done by research people and confirm what is well known, i.e., that soil levels vary more and after applications take longer to go up, and take longer to go down. Pasture leaf figures show that not enough P was being applied. Potassium figures show that too much was being applied.

The pH varied up and down between 5.8 and 6.5 despite no lime being applied. The pH in 1993 was 6, but calcium plant deficiency symptoms were visible.

Winchmore Irrigation Research Station Soil and Herbage figures

	Phosphorus				Potassium			
Yr	Soil	Change	Herbage	% Change	Soil	Change	Herbage	% Change
87	7	NA	0.53	NA	0.22	NA	2.6	NA
88	13	85%	0.62	17%	0.63	186%	3.5	35%
89	14	7%	0.59	-5%	0.32	-50%	3.0	-14%
90	9	-36%	0.54	-9%	0.33	3%	2.5	-17%
91	12	33%	0.52	-4%	0.61	85%	2.9	16%
92	14	17%	0.53	2%	0.35	-43%	3.0	3%
93	23	64%	0.53	0%	0.76	117%	2.3	-23%

Which would you believe, the highly variable soil figures in red or the less more accurate pasture ones in purple?

The optimum calcium herbage level in ryegrass is 0.8%. See Pasture Mineral Analysis columns A to W for more. When sampling it is difficult to get the ratio right, and sometimes there is no clover, so I now just measure the grass that there is most of, which gives accurate figures, because a variation has been removed.

It is pasture uptake of minerals and what the animals are eating that count, not the ridiculously variable figures shown in soils using scientist's calculations.

What a spade reveals is often of more use to those who know what to look for.

The fertiliser consultant being used went by soil tests, so said no lime was necessary. In 1993 the consultant was changed and lime was applied with beneficial results.

Look at the Fertiliser Nutrient Planner and Lime Nutrient Planner spreadsheets. They use pasture mineral analyses, so leave New Zealand's old fashioned Overseer system for dead, because it lacks accurate calcium in plant and pasture analyses, and ignores the trace element levels required for healthy soils, animals and profits. Using soil Ca, P and other soil figures makes Overseer useless. Many NZ scientists acknowledge this, and northern hemisphere ones gasp at the omission in Overseer.

I you say that so many rely on soil tests so they must be OK, you don't know how long it takes to

change farmers and the typical died in the wool scientists, and have not compared soil and pasture analyses yourself on your farm, or asked farmers who have changed to pasture analyses and been amazed at the improved, soils, pastures, animals and profits. Read Testimonials.

A supervisor on Linda Scrace's far north, Mangonui dairy farm, insisted on soil sampling which showed the pH to be 6.3 or higher, so "no lime needed".

Smart Linda Scrace got a ryegrass calcium analyses that showed calcium at 0.4% when it should be 0.8%, and achieved an excellent pasture response from applying 3,000 kg per hectare of lime, serpentine, boron and deficient trace elements (LimeMagPlus).

Northern Hemisphere concentrates and Total Mixed Ration feeders (TMR), called TMFeed in UK, know exactly the optimum levels of minerals needed by animals and supply it in feeds. They adjust their feeds (concentrates and minerals) to obtain the highest production and healthiest animals as they have done for decades. The healthy look of their animals and their high production per cow prove that they know what they are doing, despite most cows having to stand on concrete day and night. Their feeding concentrates, silage and hay, which animals were not made to eat, is not as healthy as pasture, but the minerals in the concentrates is what makes them healthier. When 100% grazing, pasture becomes the TMR, so pastures have to be analysed and then fertilised correctly through the soil to get the feed levels to optimum.

Feeding the best ten element soluble minerals in the drinking water to animals, is also necessary, because soils can't take up enough of some elements.

Whatever you do be careful. Add minerals through an online dispenser, rather than by hand for fear of over-supply. Many animals have become sick and some died from too much of a number of elements in their water, such as manganese, urea, etc., but never from Solminix.

Pasture farming without analysing mineral levels in pasture plant, is like trying to sail a ship without a rudder, and using only soil tests is making you head for rocks. Some NZ consultants getting higher commissions per test, convince some farmers that overseas soil tests are better than Hill Laboratory in Hamilton, New Zealand. Many samples come to Hill's from other countries.

High aluminium in Ca deficient soils causes hard pans and stops ryegrass roots from going down. Then when ryegrasses pull out, some who don't how to use a spade to check for a hard pan, or what to look for in soils, blamed Grassgrub decades ago and Black Beetle more recently. I've been on many farms and never found enough of either to cause the ryegrass pulling that was occurring evenly across the paddocks, when the pests were not evenly spread, if any. LimeMagPlus reduces ryegrass pulling because it gets rid of the aluminium effect that creates a hard pan.

An NZ dairy farmer going bankrupt (had to borrow $244,000) before I reversed what they were doing, emailed me, "Our consultant got a Reams soil test done by International Ag Labs in the States, which showed our boron soil level was 1.0, the desired range being 0.8 to 1.2."

A pasture analysis I did showed B to be a third of what it should be. No wonder most of USA is lower in B than New Zealand, which is very low, and they have animals dying,

Trying to work out an accurate and complete fertiliser mix from a soil test is impossible and as experienced, knowledgeable agricultural scientists and others have said, "Soil tests have very little application in soil and animal nutrition."

The first and last time I did a soil test on our farm was in 1956 (yes 1956) when I saw that they didn't give the information required and were inaccurate when relating them to mineral deficiencies, the extra pasture growth achieved from extra lime and fertiliser. When clients insisted, I did soil tests for them. They always show how inadequate they are, compared with pasture analyses, which was first done in 1920 and progressive fruit growers (New Zealand is a big fruit exporter) have used this system ever since.

Comparative figures of pasture and soil from Winchmore Irrigation Research in the South Island and many other comparisons confirm this, as do mine when consulting for 500 farmers in several countries since 1960.

Yutaka Miyawaki and I got the Japanese Department of Agriculture to do trials on six Japanese farmer clients' first pasture samples, which were sent to Hill Laboratories in Hamilton. They showed the inadequacy of fertilising based on soil tests, which had caused pasture failures because of low Ca, high Al and low B mainly, and actual animal deaths because of low Na, Se and Co, and high potassium and manganese. There was no legume nodulation because molybdenum and cobalt were so

low. Soil tests can't show these elements accurately or at all.

A soil test is a snapshot of the situation at the time done, wet or dry, whereas a pasture analysis is of about three weeks growth out of the soil. Soil tests after grazing can include urine with its high N and K, which can be seen and avoided when analysing pastures.

University tutors, taught by tutors who were taught by tutors seldom step outside of their area of education, so most advisory people and scientists will recommend soil sampling that they were taught, rather than pasture sampling, and because they have not bothered to learn how to sample and use herbage figures, they haven't seen the benefits. Some of the worst polluted pasture analysis analyses I've seen with 900 iron from soil pollution, have been from scientists. Thank goodness this is changing, but too slowly.

Laboratories continue to do soil analysing to make money. Some laboratories now acknowledge that soil testing has problems and results from soil tests are inadequate and erratic. In soils some measure P in two ways and S in three ways to try and achieve accuracy. See Hill Laboratories newsletters proving this with some minerals. One top NZ laboratory manager emailed me, "My comment on soil testing is that the 7.5 cm depth measured in New Zealand is only aimed at phosphate. It is not appropriate for most nutrients and the root zone of pasture must extend down much deeper for good growth during summer and not be affected by the physical damage of the top 7.5 cm, sometimes pugged in wet weather. I agree. Most countries use 15 cm, some 20 cm.

The nutrition of grazing animals is most important and appropriate use of pasture herbage analysis gives very good information, so I would do a visual inspection of the soil profile, root development and its depth, and put this next to the fertiliser, lime and production history and take a herbage test in spring before liming and again in autumn before fertilising. I am convinced that good recommendations can be made using this type of approach.

The comments by sheep and beef farmer Phil Taylor and many others in Free Items > Testimonials show the benefits obtained by farmers after changing to pasture plant analysing.

I know MAF technicians and USA farmers who have sent identical soil samples to different labs and got widely different levels and recommendations. With pasture herbage testing these wide variations don't occur. Those that do, are from mistakes in sampling so learn how to avoid these. One grain of soil can double the pasture plant cobalt figure and increase manganese.

The pH variations reinforce how erratic pH measurements are and how it is useless at indicating Ca requirements. In soils, the pH and phosphorus measurements can take three years to go to where they should be based on applications made, whereas pasture plant levels change within months.

Pasture Analysing

Some advisers (without sound reasons) recommend testing clover-only herbage samples, but I believe this is pointless. If no clover is available no sample can be taken. When consulting for 300 farmer clients in many countries I have frequently had to take grass only because clover was not available. Also the problem with analysing clovers only is that it is far from what the animals are eating.

The correct amount of Se in feeds raises the protein levels of milk and gives meat a redder colour and longer keeping quality.

Aluminium Al <100 Al is of no use. If high it restricts roots on some plants (especially ryegrass) from growing down, so pulling is increased. Ca and P reduce its levels.

Soil pH

A typical pH measurement tells you very little about a soil. Low earthworm numbers and soil stuck to earthworms with a dry skin, tells more and is a sure sign of low calcium that earthworms need, whereas pH doesn't show what causes the pH to be low or high, whereas pasture calcium, potassium, sodium, molybdenum and magnesium levels do tell us what is high and what is needed.

High manganese in a herbage analysis can indicate an under-drained acid wet soil needing lime, however be aware that some soil types are naturally high in manganese, so pasture levels will be high. Lime, magnesium, sodium, acidifying fertilisers, recent rain and moisture levels change the pH.

Soil Testing useless

Despite what some laboratories' claim, soil tests cannot measure some of the trace elements accurately or even at all. Take one soil sample, mix it thoroughly, divide it and send it to two labs (or in some labs even both to one lab under two paddock names) and you'll find that as found by agricultural tutor, then farmer, Phil Taylor, you've been using poor information over the years, and unfortunately using it to determine your farm's main expenditure, i.e., fertiliser and lime. See his Testimonial for more from Phil, and others.

A New Zealand fertiliser company recommended

"Get pH, Olsen-P, P-retention, CEC, Calcium base saturation %, Magnesium base saturation %, Potassium base saturation %, Sodium base saturation % and total base saturation % annually, and once every 3 to 4 years get Sulphur, and the trace elements."

How ignorant. I see low sulphur levels repeatedly on farms using Superphosphate (0-9-0-11 with N and K.) because although there is too much S in Superphosphate, it is water soluble so leaches, and takes K, Se and other elements with it, which is a waste and a polluter. The S in Superphosphate applied in autumn in winter rainfall areas can be mostly leached by spring. Less very finely ground elemental S applied in autumn with Gafsa or Sechura, supplies adequate amounts of S through winter in live soils and for nearly 12 months.

An NZ AgResearch article in April 1994 Dairying Today monthly stated, "There is no relationship between K soil tests and pasture growth in peat, coarse textured volcanic ash or in sandy pumice soils, so soil K levels should not be used, pasture ones should.

I and others believe that the recommended soil K figure used in some countries is too high, hence the high very pasture levels and the frequent animal health problems, especially metabolic ones and bloat, caused by the high K levels.

Every year there are farmers who are puzzled by the differences in the amounts of fertiliser recommended for field crops by different sources. Most people appreciate that soil testing is inaccurate, however, it is perplexing for them to get recommendations from the same analysis that differ so much.

Each year wrong fertiliser recommendations waste millions of farmer dollars in many countries, mainly though not understanding fertilising, by using soil tests, sales-people jargon, especially on some liquid products (most are not fertilisers and some cost up to $3,000 per tonne of solids), and not putting enough time and effort into working out the exact requirements. The waste also comes from low pasture yields and poor animal health because of mineral imbalances.

In the USA, a soil sample was mixed then divided and sent to 69 different laboratories. Fertilising recommendations made by each lab varied from 0 lbs per acre to 230 lbs per acre for nitrogen, and 0 to 150 for phosphate!

An NZ Rukuhia Soil Research Station technician I knew, was made to take soil samples in the 80's and could see that the adjacent similar plot recommendations he was getting from soil samples he sent to the lab were erratic, so he divided a thoroughly mixed soil into six, and got six different recommendations. He was so upset and confused and felt that he was wasting his time and working on false information, that he left the job.

In some countries laboratories make fertiliser recommendations, but New Zealand laboratories seldom do, because they realise that soil and/or pasture analysis alone can't allow for all factors. A few reasons are -

- The farmer's aims, such as maintenance, improving fertility and even saving taxation.
- High priced land warrants more fertiliser than cheaper land.
- Type of livestock. Cattle require more copper (0.13 ppm in pasture) than sheep (0.08) ppm. Dairying takes more fertility off the land than beef so needs more replacing, especially calcium.
- Livestock numbers per hectare. High stocking rates may need more fertiliser.
- Pasture types. Most new improved pasture varieties require more fertiliser than old ones because usually they've been selected under high fertility conditions.
- Rainfall. High rainfall and irrigation areas lose more through leaching and grow more pasture so need more fertiliser that should be applied before levels drop, not after.
- Organic farmers use variations of some elements.

The university of Saskatchewan developed a soil probe called the Plant Root Simulator that measures the amount of nutrients available for plant uptake. It uses special resins for absorbing soil nutrients in the same manner as plant roots do. The probes are left in the soil for up to two weeks, then removed and analysed. However, this system relies on human and electronic calculations and will still not show pasture contents, so what the animals are eating, only pasture analyses can do this.

Soil tests are usually taken from only the top 7.5 mm in NZ or 10 to 20 cm in others. Chisel ploughing can mix and bring up minerals from three times that depth to the benefit of pastures, especially clovers. Generally, clovers and crops grow much better when subsoil has been brought up. Check areas where this has occurred from ditch cleanings and where plants are growing over refilled trenches containing pipes or cables.

If for some reason I can't think of, or perhaps to check the organic matter level, you must soil test, do so to at least 150 mm (6 inches) even in New Zealand where it has been done to only 75 mm (3 inches) for decades, which is useless. Dig and see how few maize roots are in the top 75 mm. They go down to 60 cm and more, which is one reason why I and my clients who chisel plough deeply get maize silage yields of 33 tonnes per hectare while others get 20 tonnes or less, worth $5,000 less per hectare.

Organic farmers wonder why their soils look better and as if they have more organic matter, but soil tests show no significant increases. This is another problem with soil tests because laboratories dry the soil and then calculate figures on a percentage of dry weight basis. Soils high in organic matter are lighter than mineral soils so the organic matter percentages by weight don't increase as much as they should. See the pH and humus chart from six of my clients in Japan in Elements > Calcium. It is very educational.

Pasture testing

Herbage samples correctly collected and analysed by good laboratories are extremely accurate. Take a sample avoiding soil pollution, mix it thoroughly and divide it in four and send two to each of two labs and you'll see. Do the same with soil, and you'll also see, especially in USA where different laboratories use different systems. It is best to stick with one good lab.

Large forestry growers in New Zealand sample growing tips of four, nine and thirteen-year old Pinus Radiata trees (Monterey Pines) to check for fertiliser requirements. Boron is often low, causing the tips to go brown. How do they get tips from 10 metre tall trees? They shoot a piece off with a rifle.

Regarding potassium, the US Potash & Phosphate Institute, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2837, USA. Phone 770-447-0335, Fax 770-448-0439, wrote that soil K levels have decreased after applying K, but herbage levels showed an increase. A Gore, South Island, dairy farmer told me that he found the same, which make soil analyses a farce.

Identifying deficiencies

There are ways of visually identifying deficiencies of the main elements, for example most of the phosphate is excreted in the dung so if clovers are growing better around dung pats than in adjacent areas, allowing for the fact that the pats may not have been grazed because of animal avoidance, the paddock could need more P. In prolonged very dry conditions the growth could be from the moisture. If ryegrass leaves have a brown, purple, burgundy colour, especially in cold weather, P will be lacking. If clover leaves have brown spots going right through the leaves they are low in K. Urine is high in K so clover leaves are unlikely to be deficient in urine patches.

Grass in urine patches is much greener than the surrounding grass because N is so high in urine.

If clover leaves are a pale green in non-urine areas and dark green in urine patches then S is likely to be low.

A boron deficiency can cause a burgundy colour in clover leaves and the edges of leaves to be hard, brittle and die. New leaves can be a healthy green. After rain the deficiency can disappear.

Fertiliser trials

NZ AgResearch recognised that on farm fertiliser trials are the best way to be sure that you are not over or under fertilising and they developed farm trial kits to help do this.

Even with today's knowledge of pasture testing, on-farm fertiliser trials are the best for determining the optimum rates for major items such as lime, phosphate and nitrogen. Use a pasture analyses to determine which elements to apply, and then do on-farm growth trials to finalise the total quantity of growth elements to apply per hectare. Until these results have been obtained use local knowledge to decide the quantities of the main elements to apply.

See the > Trials chapter.

Vaughan Jones
Agricultural consultant & journalist
GrazingInfo Ltd