Soil Development and Testing

by Frank van Steensel

Frank van Steensel has a small farm in the Wairarapa, and also practices as a agricultural consultant. His address is PO Box 19, Greytown, ph 0-21-658 041, fax 0-21-658 042.

This topic has been on my mind for more than a decade: Why soil testing? The answer I was taught in the early eighties, the linear and dualistic way, was straight forward. Soil testing supported the farmer in his decision making - how much and which fertilizers did he require and could afford each year to obtain maximum production? Since the agricultural course I did was to a large extent conventional, especially the soil science and water management part of it, this was not a strange conclusion. But as time went on, and I dealt more and more with practical situations, I began to have doubts about that approach.

Doubts particularly entered my mind when I learned about low-input systems. Time spent in an aid program educating farmers in central Honduras on soil conservation and soil fertility also opened a new window. The project promoted compost making as one of the major activities, and I was the person educating the farmers on compost. It started my love affair with compost. I quickly discovered that humus, not any chemical, is the essential soil 'element'. Understanding the virtue of compost involves biochemistry and this is as close as modern science gets to a 'living science'(E. Pfeiffer, 1958). After writing a thesis on compost and doing research into soil quality the question 'Why soil testing?' started to live in me again. My approach towards science had evolved from linear thinking towards a more holistic approach.

Modern standard soil tests ignore humus completely because most conventional institutes still rely on analytical and linear approaches. With the recent recognition by the Soil Science Society of America of soil quality (see *Harvests* Vol. 50, No. 2, Spring 1997, p18), laboratories and other institutions the world over are showing more interest in soil organic matter[1] and organic farming systems.

For a while I thought "If I were a farmer I would not use soil test at all. If I used mature compost in sufficient quantities all my problems would disappear". Though I still think this is 'generally' true, for commercial farmers such a conclusion is too simplistic.

The fertiliser recommendations coming with the standard soil test make sure that farmers need to buy more fertilizers each year to keep up their production. For these fertilisers to become available to plants and micro-organisms energy is needed, and that energy comes from oxidising (or "burning") the humus buffer (stored sun energy) out of the soil. This of course lowers the humus content, resulting in a decrease in soil quality, and so the farmer becomes more and more dependent on further agrochemical inputs. In this manner the farmer is not supporting his family but the corporate interest that is supplying the agrochemicals.

Research into soil quality made me realise that there are parameters that can be useful if placed in the right context and integrated into a wholistic, ecological, or anthroposophical vision.

So why soil testing? *Soil tests can be useful in understanding your soil.* Appropriate soil testing has the potential to help you paint a picture of your soil and soil development over time. But the emphasis should be on soil quality parameters rather than soil fertility parameters.

Before using expensive soil tests it is worthwhile gathering some insights into soil and soil development. These can become your primary tool. Understanding soils and your soil in particular involves a few steps. It starts with the big picture first (phenomenological or holistic) and only then goes on to examine the details of your particular farm or garden (for example by observing soil structure and by soil testing).

The big picture

To develop the big picture I find a phenomenological approach very satisfying (phenomenology is derived from Goethean Science). I studied the major soils of the world and soil developments as a part of the curriculum for my employment in Central America. From this I obtained a clear insight that soils act as living organisms[2]. They are born, go through a juvenile phase, stabilise in a mature phase and degenerate into a rigid 'dead' soil. This development is largely influenced by the environment and most soils do not reach maturity or their 'full potential'. That can be said for every organism, and it is the environment that sets the boundaries. This does not mean that every mature soil is the same, because no living organisms are identical; each individual or system has

[1] Soil organic matter is not the same as humus, but humus is a part of the organic matter content of the soil. It is the part that is the basis for the 'quality' or 'health' of a soil.

[2] Soil classification is largely based on the 'age' of a soil, distinguished in 'unrecognisable parameters' such as CEC, Ec, pH, etc..

its own potential. Generalisations help but are never the whole truth; nothing is black or white, everything is coloured.

An example of the developmental phase of a soil and its matching ecosystem reaching full potential can give a lot of insight into nature and agriculture. Les Molloy in his splendid book *The Living Mantle* (1993) shows great insight with his New Zealand example. On page 19 he shows how soil and matching vegetation develop together. The nutrient graph is an important feature, and a lot of hidden clues can be found in it concerning nutrient management on the farm. The subject would be worth another article.

The juvenile and mature stage that succeeds it have different characteristics, as shown in the table below.

Juvenile and mature stages of soils and ecosystems compared

	Juvenile	Mature
Plant species	one or few	lots
Number of individuals per spp.	lots	few
Plant types	annual or biannual herbs	one-, two - and more year herbs, shrubs, trees, mosses, ferns, etc
Animal species	few	lots
Relationships	simple	complex; specialism
Biomass	growth; increasing annually	growth and decay in balance
Environment	extreme;	regulating
(fluctuations)	'plant unfriendly'	
Soil	mineral, unripened	ripened, with organic matter and humus
	high inorganic P	high organic P
	high pH	neutral pH
	low CEC	high CEC

There are many interesting clues in this table. One important insight is that during development the soil changes from pure 'earthly substance ' to a more 'cosmic substance' - for example by capturing more 'sun energy' and storing it in (soil) organic matter and biomass. This can be a 'buffer' against disturbances from outside. Eventually the system tarts to lose this 'buffer' and deteriorates, becomes old.

Young soils have different characteristics from mature and old soils. Young soils, like children, are dynamic but susceptible, mature soils, like (most) adults, are more stable, while old soils become rigid and stiff, like the elderly. Different management seems to be advisable.

I have remarked that soil classification is mainly based on the 'age' of a soil. A soil belongs to a certain class or type if it has certain properties, which are measured by various parameters. The measuring of these parameters is also a form of soil testing. Since most of NZ soils are already surveyed this information is available from regional councils, and it can be a start in getting aquainted with your soil. The next step can be to analyse the details on the farm, get a soil audit from every soil class or type you have on the farm. You might like to subdivide them for audit purposes if they are under different management. In the soil audit I recommend the following parameters:

- Soil structure *(this is a major factor in agriculture)*, needs to be assessed in the field
- Texture
- Carbon /Nitrogen ratio (also gives soil organic matter)
- Cation Exchange Capacity (CEC)
- Base saturation plus percentages of K, CA, Mg, S.
- pH (if pH is lower than 5.5 more information is required, because then phosphorus fixation can be a challenge - a reasonably common factor in the tropics and some parts of NZ)
- Earthworm casts as a indicator for soil biological activity

Trace element data can be of as much value as soluble P or Olsen P. These parameters can be important during the conversion period.

The parameters mentioned above can reveal what is happening in your soil over time. They can be used to assess the requirements of a living soil (for example: for dolomite or lime; for the amount and quality of compost[3]). So testing the soil with these parameters and then keeping the records means you are building up a library of soil 'pictures' with hidden information, while on the other hand you can account for the maintenance requirements of your soil.

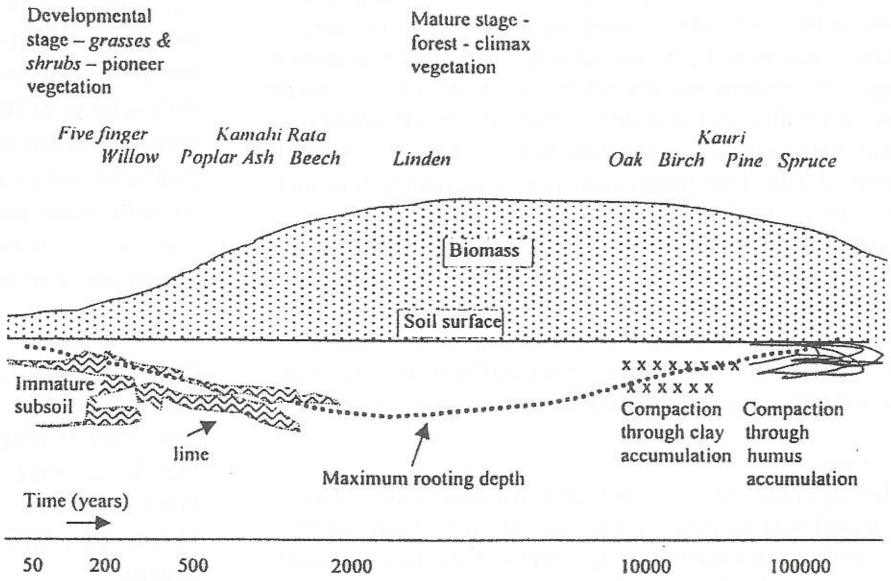
So in short my suggestion is:
First find out more about your soil, young, mature or old/grey. Think this over and compare it with your observations. Adjust your management if you deem it necessary.

[3] In my view the only **material** inputs needed for organic farming systems, though an additional input of seaweed or powdered rock can be jusitfied.

econdly start taking regular soil tests, and keep referring to them every year to follow the soil development. It can provide you with information on changes, answering questions like: "Did a change of management show up on the test results?", and "Was it good or bad?"

For me personally the major break through in my understanding of soils, agricultural systems or life for that matter came when I discovered that true answers do not only come from linear, dualistic, analytical, contracting or conventional thinking. Growth, any growth requires synthesis and expansion as well. Biochemistry, ecology, phenomenology and holistic approaches can provide these.

Soil and vegetation development on drained, lime-rich alluvial clay soil[4].



Some points to note:

- There are rapid changes in the beginning.
- There is more stability in the middle period, with fertile dynamic soils that are relatively disturbance resistant, with a high internal resistance. Trees are placed firmly in and 'on' the soil with deep rooting systems. The annual rhythm is definitely present. This is the climax stage.
- In the 'final' stage trees have less rooting depth. The landscape has a more rigid and stiff character.

The Development of a Soil[4]

An alluvial recently developed clay soil

Each soil has its own advantages and disadvantages, and each soil characteristic has a reason. The different characteristics arise during the development of the soil and its matching (natural, semi-natural, agricultural) landscape. The evolution of soils and landscapes can give good insights into soil problems. An example of soil and landscape succession is given here:

First stage

The first soil is a juvenile lime-rich sea clay. Organic matter is about 7% and there is a high calcium carbonate content (20%). An example is soils on the outside of the dike in The Netherlands. These soils are flooded twice a day; shrubs and trees do not exist. The vegetation is mainly salt resistant herbs - mainly grasses. The fauna are mainly voluminous and loud birds: *Laridea* (gulls, sterns), *Anatidae* (ducks and geese), *Haematopodidae (*oyster-catchers), *Charadriidae* (plovers and dotterels), *Scolopcidae* (sandpipers and snipes) and so on. At high tide the water is quiet and sediment will settle in amongst the vegetation. At low tide the soil will not dry and air does not penetrate it; consequently the soil stays wet and plastic. Dead organic matter is decomposed anaerobically to a smelly product. Sulphur and water are freed from proteins by bacteria and react with iron from the soil to form blue to blue-black sulphur compounds.

Second stage

Dikes can protect the juvenile lime-rich sea-clay soil against flooding. Good drainage can lead to a change in vegetation; willows and alders then become the dominant trees - 'watery' trees that grow fast and are wind-pollinated. The fauna changes to *Ardeidae* (herons, egrets) and on the more open landscapes meadow birds become predominant.

The soil loses a lot of water, especially in the summer through the vegetation – transpiration. The soil ripens, and becomes more firm; cracks appear and air penetrates. Dead organic matter starts to decay aerobically especially in the top-soil where soil life becomes active, and where humus is formed on the topsoil. Lime is still in surplus (10% of the soil mass can be more or less finely divided lime). Note that if there is no lime the development of humus and the ripening of the soil are different. In that case there will be peat formation, gley formation, high water table and poor aeration. With a high evaporation as in the tropics and no leaching or rain surplus the soil becomes more silty.

Third stage

After ripening to a significant depth the soil and matching landscape develops further. Stable humus is not yet present in significant amounts but the soil is made more porous by worms. The subsoil also has a sponge like structure. Poplars start to dominate the landscape together with ash. Trees are still mostly wind pollinated and the landscape has a strong green 'vegetative' or 'spring' appearance.

Fourth stage

The more developed clay soils are undergoing a deliming process. The assimilation and dissimilation of soil life, together with the decomposition of organic matter creates acids and by them

[4]Discussion and diagram adapted from article by J Bokhorst, Louis Bolk Institute, Driebergen, Netherlands, by kind permission of the author.

lime is dissolved. During high rainfall the lime will leach out of the topsoil and subsoil, and the pH will decrease to below 7.0. Along with this change in pH the soil life changes. Because of the lower lime content the decay of organic matter is now steadier and a bit slower and stable humus is formed. Larger soil animals mix the soil and homogenise it. A deeper root zone with a higher humus content is created which can retain more moisture, so creating better conditions for plant growth. Trees of the family *Rosaseae* are found in this landscape, trees often with colourful and/ or large fruits. Beeches, lindens and several different oaks predominate in the landscape - trees with firm wood having many uses. In spring singing birds are very noticeable; heavy colouring in autumn is also very typical. The landscape shows colours, has orchestral sounds, insects. One could also say that it has summer and autumn characteristics - warmth and ripening.

Fifth stage

Deliming continues until the lime is leached totally; there is no natural balance keeping a certain amount of lime in the soil. Soil life and decomposing material keep forming acids which eventually dissolve all the lime, first of all in the topsoil. On older river clay soils in the Netherlands the lime has even disappeared from the subsoil. This deliming process takes several thousands of years. We still find the same trees as in stage four, but oak trees tend to become dominant.

Sixth stage

When the leaching of lime is completed the leaching of luteum (soil particles less than 0.002 mm) and humus starts. Humus is also lost through cracks in the soil that develop during dry periods in the summer. The topsoil becomes more sandy and a layer 30-60 cm deep becomes less sandy. This is the leaching layer where luteum collects. Complete hardening of this layer will take 10,000 years. Fruit trees will slowly disappear; the oak takes over and the birch shows its face as do pines and conifers. More shrubs appear. The singing bird population declines; tits and more predatory birds appear. Autumn colours are still there but the abundance of colours as in beeches and lindens is gone.

Seventh stage

Development still goes on but becomes harder to trace. Podzol soils could be the next stage. A clear humus leaching layer may over several tens of thousands of years. The consequence for these soils is that they become impermeable to roots.

The above is an example from a succession on clay soil with a high lime content. It is summarised in the diagram on the previous page. Sandy soils with a high lime content show the same but faster development. Each soil, with its matching landscape goes from a juvenile stage to mature and old stage, losing first of all easily soluble elements such as calcium, magnesium, sulphur and potassium, then less soluble compounds until aluminum remains predominant, as for example in the red, totally leached soils of the tropics.

There are some important observations in this for farmers. Soils are different and need different management. The ideal would be a stable mature soil. Appropriate management can stimulate young as well as old soils in that direction. Young soils need to be supported in the ripening or maturing processes. Old soils need measures to lose rigid characteristics – measures such as sub soiling. Another option is using liming old soils which increases mineralisation. Measurements that seem to work in the short term can be harmful in the long run – measures such as sub-soiling young clay soils.

References

Bokhorst, J in P.A. van der Werff (Ed.), 1992. *Toegepaste Bodemecologie in de Alternatieve Landbouw*, 3rd Edition, University of Wageningen.

Pfeiffer, E., 1958. *Subnature and Supernature*, Mercury Press 1981.

Molloy, Les, 1993. *The Living Mantle*, NZ Society of Soil Science.

Some Background Points

by Peter Lester

Peter Lester runs Quantum Laboratory in Hawke's Bay, where he has some biodynamic farmers among his clients, and was a speaker at a recent local biodynamic group fieldday. This article is composed of extracts selected by the editor from his booklet *Flash Point*, and is reprinted here with Peter's permission. His address is 24 Shanley St, Waipawa, ph 0-6-857 7333, fax 0-6-857 7999.

Historical evidence

The fact that the animal is a product of the soil was evident to our ancestors hundreds, if not thousands of years ago. Moses wrote in the book of Genesis; "*dust thou art, and to dust thou shall return*". That statement was not the basis for some religious and philosophical doctrine, but was in fact a monumentous scientific truth, as stated by Andre Voisin in his book *Soil, Grass and Cancer,* which should be engraved over the entrance of every faculty of medicine in the world.

Isaiah too proclaimed the unequivocal truth that "*all flesh is grass*".

Our ancestors were well aware of the fact that it is the "dust" of the soil that finally determines our vigour and our health. Even pre-historic man knew that certain areas were better for rearing livestock than others; they valued these above all else, in fact they fought wars over them. Soil fertility spelt survival.