Why Biodynamics Works

John Bradshaw

Conventional agriculture uses artificial water soluble fertilisers to feed plants through the soil water. Organic/Biodynamic agriculture use composts, manures (though never direct on food crops) and green manures with the addition of non-water soluble fertilisers when necessary, and aims to feed plants naturally through the soil humus. In addition, Biodynamic agriculture uses the Biodynamic preparations, which powerfully develop microbial activity, root growth, and humus production in the soil, and one of which enhances light metabolism in the leaves. The experience of thousands of growers using the Australian Demeter Biodynamic method (worldwide) has been that they require far lower fertiliser inputs than equivalent conventional or organic farmers. Indeed there have been cases where no fertilizer inputs have been used on BD farms for decades, while production continues at high levels. Why is this so?

The plant stands in the midst of Cosmos and Earth in the most complex and refined system of interrelationships imaginable. In Nature, this most highly organised system has obviously enabled plants to thrive, since time immemorial, without any human intervention at all.

When humanity was at the hunter-gatherer stage, we simply harvested the bounty that Nature provided. When, later (particularly led by the great inspirer, Zarathustra), we began cultivating plants and herding animals, the development towards settled societies and the growth of great civilizations became possible. As farmers, we still essentially supported and worked with the natural system of plant growth.

The most basic of farming systems, slash and burn, relied on Nature to progressively rebuild humus levels in soils as they reverted to a natural state after one season's or one year's cultivation had depleted the soil humus. Floodplain farming relied on the annual deposition of humus-rich silt by flooding rivers. As populations grew, more sophisticated farming systems were developed. It took some time for the level of sophistication to develop, and where soils were pushed too hard, and humus levels declined, problems occurred. Where soils became too depleted, deserts encroached and civilizations fell.

The culmination of agricultural development before the artificial fertiliser age was the most careful, intelligent peasant farming of Europe. All wastes were recycled and returned to the land, either fully composted or spread on melting snows to be incorporated into soil humus before crops were sown. Highly sophisticated rotational systems were developed to ensure that soils were maintained in a humus rich, fertile state. Ploughing was done with meticulous care and sensitivity, to preserve and improve the vitally important soil structure. From the many monastery records available, we can see that productivity was high and that pests and diseases were of minor significance.

With the development of science, understanding of *how* and *why* things worked became more and more important. In the late 18th century, German agronomist Albrecht Thaer (1752-1828), advanced the idea that soil fertility was based on the level of soil humus, and that humus constituted plant food. He regarded humus as a biological-functional performance of the earth that should be viewed holistically. He believed that inorganic salts were unnecessary for plant nutrition.

In the 1840s, Justus von Liebig showed that, in fact plants could only absorb nutrients in a water soluble state. This discovery led to the development of water soluble ("artificial") fertilizers, and the hasty and ill-considered disregarding of humus as a critical factor in plant nutrition. In fact, von Liebig realized this mistake late in life and wrote of the critical importance of humus. However, neither scientists, excited by the newly discovered facts of plant nutrition, nor those involved in the fast developing artificial fertilizer industry, paused to consider Liebig's later realizations.

At first, soluble phosphates applied to soils seemed to produce dramatic results. Crop yields increased. As the years passed, the early growth boost from soluble phosphates declined, while problems with pests, diseases, animal health and seed vitality increased. Phosphate application rates had to be progressively increased to get the same response from plants. Soluble forms of nitrogen were developed and later, potassium, and progressively more trace elements were added to the repertoire to keep crop yields up. Humus levels, meanwhile, progressively declined.

Agricultural scientists repeatedly claim that organic crops have serious problems with pests and diseases, but the reverse is actually true. It is the artificially fertilized crops that are attacked by all manner of pests and diseases, and have to be sprayed with insecticides and fungicides to survive. It is common knowledge amongst Biodynamic growers (and many organic growers), that their crops are not generally troubled by pests and diseases and do not require protection. It is also common knowledge that animals on Biodynamic farms are healthier and more fertile[1]. Consumers and retailers know that food produced on Biodynamic farms (and good organic farms) has a much longer shelf life than that from conventional farms. Should this not make

[1] The freedom from pests and diseases and the health and fertility of BD animals have been established by published research papers, and are repeatedly confirmed in farm interviews such as those published in this magazine.

agricultural scientists rethink their whole system, and question whether perhaps it has some major flaw?

How Plants Grow in a Natural System

As Alex Podolinsky puts it "Plants are children of the sun, scientifically speaking, and not of earth."[2] It is the sun that sustains all life on earth, through the sun-inspired photosynthesis of plants. The soluble nutrient theory of plant feeding ignores the role of humus and the sun's role in directing plant nutrient uptake from humus.

No-one disputes the fact that plant roots can only absorb nutrients in solution, but the overall picture of plant feeding is very different depending whether the source of the nutrients is water soluble fertilizers or water soluble nutrients contained in colloidal humus[3].

Colloidal Humus

In a natural system, the teeming life of the soil works to convert organic matter into colloidal humus. Any minerals in soluble form are also incorporated in colloidal humus. Organic matter consists of dead roots, leaves and other plant material, manures, and the dead bodies of soil fauna and flora. Colloidal humus (a colloid is between a suspension and a solution. Other colloids include butter and jelly) holds minerals in a soluble form, but will not allow them to leach out. It can hold up to 75% of its own volume as water, and dries out very slowly. Plant roots can access the soluble nutrients held within the humus colloid, and in fact can take in the colloidal humus completely.

The plant has no warmth mechanism as have animals, and is entirely dependent on the sun's warmth to tell it when to feed. When sun warmth indicates, fine hair feeder roots take in nutrients from colloidal humus in the soil. Plants need to take in water to replace that lost in transpiration from the leaves. The water is taken in mostly by larger, thicker roots, and the water taken in is relatively free of dissolved minerals (because no soluble fertilizers have been applied, and because the teeming soil life works constantly to build organic matter and any soluble minerals into colloidal humus). Thus nutrient uptake matches the sun warmth directive, and a healthy nutritious plant results. The plant is, in general, not attractive to insects, and is resistant to disease. This is the result when plants are fed from soil humus according to Nature's design.

By contrast, when water soluble fertilizers are applied, the minerals dissolve in and spread throughout the soil water. The plant is forced to take up nutrients when it takes up water, no matter whether sun warmth is present or not. The plant thus takes in more minerals than it needs metabolically. Cells become overfull with mineral salts. The plant tries to take in more water to dilute these minerals but only succeeds in making matters worse. Plant cells become distended with too much water and salts. Water movement in the plant is hampered, and the photosynthetic shutter cells on the leaf stomata cannot open and shut freely, resulting in lowered photosynthetic activity. An altogether un-natural plant. These plants have poor nutritional quality, poor flavour, are more attractive to insects, more susceptible to disease, and rot more quickly after harvest.

Soil Life

A myriad of living organisms work together in the soil to break down organic matter and transform it into stable colloidal humus, the ideal plant food. Other organisms work together with plants to fix atmospheric nitrogen and to assist plant roots in finding and absorbing nutrients. *The primary function of soil life is to assist plants to feed naturally, as directed by the sun*. It is awe-inspiring to consider the immensely intelligent organization of Nature. Without this teeming, well organised and coordinated soil life, nature would simply cease to function.

Soil Animals – soil animals range from the tiny microfauna, such as protozoa, through the mesofauna such as mites, collembola (springtails) and nematodes, to the macrofauna such as ants, earthworms, beetles and termites. Soil animals break down or shred organic matter, increasing its surface area, allowing micro-organisms to work on it more effectively. They help aerate the soil and assist in the formation of soil aggregates. Their excreta contribute to soil fertility.

Earthworms – are among the most important of the soil animals. French scientist and ecologist André Voisin referred to earthworms as the "foundation of all civilization". They eat dead roots, leaves and other organic matter, together with large amounts of soil, fungi and bacteria as they tunnel. Their tunnelling aerates and mixes the soil, and greatly increases its overall volume and water holding capacity. Earthworms can reduce small stones (up to 1.25mm) to paste, and break up clods. Their worm casts are pure colloidal humus, and contain five times the nitrogen, seven times the phosphorus and eleven times the potassium of the surrounding soil. Wormcasts are almost neutral in pH. Worm tunnels are lined with humus rich substances, and plant roots can use them to delve deeper in the soil absorbing the humus lining as they go. When a root dies (as for example when pasture is grazed down in a rotational system), a worm will eat it and re-establish the tunnel, or build a new tunnel where the root was.

Soil Fungi – are very effective at breaking down dead cell walls, cellulose and lignin. They are very active in the early stages of organic matter breakdown, as seen in the healthy white fungal activity in the early breakdown stages in a compost heap (as distinguished from the white material associated with overheating and "burning" of compost). Once the early stages of organic

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[2] *Bio-Dynamic Agriculture, Introductory Lectures, Vol. 1*, Alex Podolinsky, 1985, Gavemer Publishing, Sydney, p28

[3] The overall picture of natural plant feeding was first clearly seen and described by Alex Podolinsky over 50 years ago.

matter breakdown are completed by the fungi, bacteria become predominant.

Mycorrhizal fungi are specialized fungi that form mutually beneficial associations with plant roots. There are four main types of mycorrhizal fungi. The most common type is the vesicular arbuscular mycorrhizae or VAM. They can form beneficial associations with most plants. The mycorrhizal fungi penetrate plant roots, and extend very fine hyphae out into the soil. They receive nutrients such as carbohydrates from the plant roots, and bring nutrients from the soil to the plant roots. They help form soil aggregates, help the plant resist drought and are very effective at finding phosphorus and many trace elements in deficient soils. They also help the plant resist soil-borne pathogens.

Mycorrhizal fungi (white areas) with cocksfoot roots

Soil Bacteria – single celled organisms which can reproduce and proliferate extremely quickly when conditions are right. Most soil bacteria live close to plant roots. Most beneficial bacteria are aerobic, meaning that they require oxygen. Anaerobic bacteria do not require oxygen, and tend to cause putrefaction of organic matter rather than its healthy breakdown to humus.

Of the many, many classes of bacteria in soils, some of the most important are: **actinobacteria**, which play a crucial role in the transforming of organic matter into humus, and give healthy soil its earthy aroma; **independent nitrogen fixing bacteria**, which convert ammonium (from decomposing proteins) into nitrates which are incorporated in the soil humus; **azobacter**, free living bacteria that convert atmospheric nitrogen into forms usable by plants; and **rhizobia**, a group of bacteria that form symbiotic relationships with the roots of leguminous plants and take nitrogen from the air, converting it (using an enzyme called nitrogenase), into a form of nitrogen usable by plants. They are called nitrogen fixers. Depending on the type of plant, the rhizobia bacteria enter the plant root either directly through the root surface, or by the fine root hairs curling around the bacteria to help them enter. Once inside, they multiply, as do the root hair cells. Nodules are formed. Within the nodules, nitrogenase is protected from oxygen (which hampers its activity) by another enzyme, leghaemoblobin, which takes the oxygen away to respiratory sites. It is leghaemoglobin that gives the inside of the nodules their characteristic pink colouring.

Nitrogen fixing Rhizobia on white clover roots

Soil Enzymes

Soil enzymes (and co-enzymes) play a very important, and as yet only partly understood role in the functioning of the soil/plant ecosystem. They are synthesized by plants, animals, mould, fungi, yeasts and bacteria, and are in a never-ending cycle, being constantly synthesized, concentrated, de-activated and decomposed. They are involved in many biochemical processes and play a key role in the breakdown of organic material and its conversion to colloidal humus, the cycling of nutrients, and the building of soil structure. Some enzymes active in the soil ecosystem include amylase, arylsulphatases, ß-glucosidase, cellulase, chitinase, dehydrogenase, phosphatase, protease and urease. There are many more, and many more are still to be discovered[4].

Biological Transmutations

It is becoming increasingly clear (though not yet accepted by many mainstream scientists) that, in a living biological system, elements can transmute into other elements. This is the inescapable conclusion of much meticulous research and many observations that are inconsistent with the generally accepted view that an element is a substance that cannot be broken down by chemical means.

Research that supports this idea includes: in 1799, Vauquelin found that a hen excreted 5 times more lime than it ingested; in 1822, Prout discovered that limestone in an incubating chicken egg increases overall; in 1831, Choubard found that germinated seeds contained minerals that were not present originally in the seeds; in 1844, Vogel found that, after germination, watercress contained more sulphur than was in the seeds.

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[4] See *Selected soil enzymes; Examples of their potential roles in the ecosystem*, Makoi, J.H.J.R. and Ndakidemi, P.A. in African Journal of Biotechnology Vol 7 (3) pp. 181-191, Feb. 5th 2008 for a very interesting discussion of soil enzymes.

In 1879, Albrect von Herzeele published the results of many experiments which strongly supported the idea that elements can change from one into another. Some of the reactions he demonstrated included:
$H_2CO_3 \rightarrow Mg \rightarrow Ca \rightarrow P \rightarrow S \rightarrow N \rightarrow K$.

How is this possible? Conventional understanding is that elements can combine in chemical reactions to form molecules, and that molecules can break down into individual elements, but that elements themselves cannot normally change.

A chemical element is a pure substance composed of one type of atom. Elements are distinguished from one another by the number of protons (positively charged particles) in the atomic nucleus. The lightest element, Hydrogen, has one proton in its nucleus, giving it an atomic number of 1. Uranium is the heaviest naturally occurring element, with 92 protons and therefore the atomic number 92. Biological transmutation occurs when an element merges with another element, combining their protons in a single new nucleus thus becoming a third element, or conversely, when an element breaks down into two new elements with separate nuclei.

It is accepted by mainstream science that in certain circumstances elements *can* change: when a cosmic ray neutron (electrically neutral particle) hits a nitrogen atom (7 protons), it breaks down into carbon (6 protons) and hydrogen (1 proton). Isotopes (variations in the number of *neutrons* in an atomic nucleus) are involved but we won't go into that here.

The element uranium breaks down (very slowly) in nature in the following sequence (again involving isotopes): uranium to thorium to protactinium to uranium (different isotope) to radium to radon to polonium to lead to bismuth, and, after fluctuating between various isotopes of lead, bismuth and polonium, eventually decays into a stable form of lead.

Professor Louis Kervran (University of Paris) began publishing the results of his experiments on what he called biological transmutations in 1959. He found that the most important and abundant biological transmutations occur amongst the first twenty elements of the periodic table and to a lesser extent with the next ten. Many transmutations have been established. Although the exact mechanism of biological transmutation is still to be discovered, Prof. Kervran suggested that enzymes are probably integral to the process. Scientists who have confirmed some of his findings include: Prof. Dr. Hisatoki Komaki, Japan, Prof. Baranger (France), and J.E. Zundel (Switzerland).

Leaving aside the issue of different isotopes, and expressing the atomic number only, some of the biological transmutations that have been discovered (many of which are reversible) include[5]:

$_{11}Na + _{8}O = _{19}K$	$_{19}K + _{1}H = _{20}Ca$
$_{12}Mg + _{8}O = _{20}Ca$	$_{14}Si + _{6}C = _{20}Ca$
$_{11}Na + _{1}H = _{12}Mg$	$_{11}Na = _{3}Li + _{8}O$
$_{12}Mg + _{3}Li = _{15}P$	$_{17}Cl - _{8}O = _{9}F$
$_{15}P = _{6}C + _{9}F$	$_{8}O + _{8}O = _{16}S$
$_{26}Fe - _{1}H = _{25}Mn$	$_{7}N + _{12}Mg = _{19}K$

This is only a sample of the many reactions which have been shown to occur[6]. The implications for farming, diet and medicine are intriguing. Instead of trying to replace elements that appear to be lacking we might be better to consider biological transmutations carefully. For instance it may well be (there is some evidence) that calcium deficiency in humans could be better treated with magnesium or organic silica (both of which can biologically transmute into calcium), than with calcium supplements. In agriculture, potassium can be formed from transmuted calcium (in combination with hydrogen), and so on.

The very idea of "soil analysis" is called into question, when dealing with the biologically active soils found on Biodynamic and organic farms and gardens. Where soil life is abundant, there are many active cycles occurring. Nature is constantly trying to achieve balance, to redress imbalance, so that healthy plant growth can continue. A soil test is a snapshot in time. One hour after the "snapshot", the situation may have changed considerably. In 2004, the Australian Soil and Plant Testing Council sent *standardised* soil samples to 18 laboratories across the country. The results for nitrogen, phosphorus and potassium varied so dramatically that laboratory standards were called into question, even though the same testing methodology was used. Could it be that, once the samples were divided up, variations in temperature, elevation, pressure, microbial and fungal content, or other factors, could have caused the wide divergence via biological transmutation?

It would appear to be much more sensible for a farmer to look at the whole living system on his/her farm to assess the needs of the plants, including how well or poorly things are growing, the predominance of particular weed species, the health status of animals etc., than relying on an unscientific and inaccurate soil test.

Sun and Air

In discussing plant growth we tend to focus on soil factors, and forget that without sun and air there would be no plants at all. The sun provides the primal energy for photosynthesis, the only truly original manufacturing process on Earth. Air provides the carbon dioxide

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[5] C=carbon, Ca=calcium, Cl=chlorine, F=fluorine, Fe=iron, H=hydrogen, K=potassium, Li=lithium, Mg=magnesium, Mn=manganese, N=nitrogen, Na=sodium, O=oxygen, P=phosphorus, S=sulphur, Si=silicon,

[6] See *Biological Transmutations*, Professor C. Louis Kervran, Happiness Press, California, 1980 for more examples.

necessary for photosynthesis to occur, as well as nitrogen that is brought into soils by independent azobacter bacteria, and rhizobia bacteria in conjunction with plants. We must also remember that plant leaves can take in other nutrients from the air – all elements are present in air, in minutest quantities. We still don't understand how relevant this is to plant nutrition, although the fact that leaves *can* take in nutrients has been abused by proponents of foliar feeding, who apply nutrients via foliar sprays, thus subverting the natural, sun-directed plant feeding process.

Biodynamics

Professor Kervran makes the point that in agriculture, for biological transmutations to work, the soil must be alive, rich in microorganisms, and that adequate humus must be present. He also comments that all plants are different. For instance, some plants can make their own calcium in a calcium deficient soil whereas others can not. The same applies to other major and minor elements. Each plant has different root types and structures, and releases different exudates from its roots. Each plant lives in, fosters, and is fostered by, a unique community of bacteria and fungi.

We simply don't know how many different species of living things are in the soil or understand the complex interrelationships that exist, or how they vary from plant to plant. We don't know the full range of enzymes and coenzymes that are produced by plants and soil macro and micro-life or the biological transmutations they, the micro-organisms and possibly creatures such as worms might foster.

There is no question that the correct use of properly made and stored Biodynamic preparations enormously enhances soil biological activity. Organic matter levels in soils rise significantly. Microbial activity is greatly enhanced, root growth fostered[7], and colloidal humus formation promoted. As a direct result of this enhanced activity, soil colour darkens progressively, and soil structure improves. It is actively growing roots, in conjunction with soil biology that create and develop soil structure. Soils become deeper, even heavy clays becoming friable soil in time. Such dramatic soil changes, which soil scientists have stated would take Nature alone thousands of years to achieve, have only been achieved through the use of the Biodynamic preparations.

The soil spray 500 is a very concentrated source of microbes, as are the six compost preparations which are used in compost heaps and added to 500 to make the even more potent "prepared 500". Dr. Pfeiffer, who was entrusted by Rudolf Steiner with researching the best ways of making and applying the BD preparations, discovered several novel microbe species in them. Sprayed on moist soil that is not too cold, the BD preparations have a unique and dramatic soil enlivening effect. The conditions for a rich soil ecosystem are well and truly established by their correct use.

Hand in hand with the use of the Biodynamic preparations goes a wide range of agricultural practices that have been developed since the late 1940s by Alex Podolinsky and the farmers of the Bio-Dynamic Agricultural Association of Australia. The whole focus of the Australian Demeter Biodynamic method is to foster the development of soil conditions that best enable the soil ecosystem to work at optimum effectiveness, resulting in the most vibrantly healthy, nutritious and delicious food. Some of the main Biodynamic agricultural practices are:

Rotational Grazing of Biodiverse Pasture

Pasture is divided up into many paddocks, at least five on a small farm, or up to thirty five or forty on a dairy farm. Stock are rotated regularly so that after a pasture is eaten down, it has time to grow back to an optimum height before again being grazed. After each grazing, many plant roots die, and are devoured by the soil life. Worm tunnels are created, which are again occupied by roots. The pasture roots go progressively deeper under rotational grazing, hand in hand with soil structuring and aeration. After grazing by cattle, pastures are harrowed (usually with split truck tyre "smudgers") to spread the valuable manure, a form of "sheet composting". The thinly spread manure is quickly digested and incorporated in soil humus by worms and microbes. Harrowing is not necessary if dung beetles are active, and is avoided when soils are wet enough to risk compaction by tractor tyres.

There is no doubt that permanent pasture is the best use of land for the development of the soil in terms of biological activity, soil structure, depth, and humus development. Peter Andrews, in his book *Back From the Brink*[8] describes a visit to one of the top racehorse stables in England in the 1960s. He complimented the manager on his pastures saying that they appeared to be free of weeds. The manager was obviously upset by this[9], and Peter later discovered that traditional English horse breeders considered that a good horse breeding pasture should contain at least 80 species. If the pasture had less than 40 species, it was considered to be in decline. When Peter had a closer look at the pasture he found many species of weeds there, in large numbers. The other essential was that pastures should never be ploughed, as experience had shown that when a pasture was ploughed, it would be no good for young horses for five years and would not produce a Group 1 winner for ten years. During the Second World War, English horse

[7] Paul Madder, the main soil researcher at FiBL (Forschungsinstitut für biologischen Landbau - Research Institute of Organic Agriculture, Landbau, Switzerland) found that Biodynamic roots are more active towards creating humus than organic or conventional roots.

[8] ABC Books, Sydney, 2006

[9] The manager was also shocked when Peter asked if he used superphosphate, exclaiming "*What!*"

studs were compelled to plough their pastures to grow vegetables. When the militia arrived at this particular stud to make them comply, father and son stood at the front gate with shotguns until they relented.

Biodynamic pastures are composed of many species, the more the better, and weeds are generally regarded as useful contributors to the overall nutrition and biological activity of the pasture. Many "weeds" that would cause digestive disturbances or be avoided by animals on conventional farms, are relished and easily digested by animals on Biodynamic farms. Native grasses are also encouraged. Each plant species (including the "weeds") brings a different quality to the soil, and benefits to the animals that graze. The large variety of species, each with its own unique biological activity, its own community of fungi and bacteria, enzymes and coenzymes, gives Nature a sufficiently varied palette to work with, to fulfil its aim of developing colloidal humus and bringing a balanced supply of nutrients to plants. Photosynthesis brings carbon in the form of sugars into plants and in turn into the soil. Legumes, in partnership with their co-working rhizobia, bring atmospheric nitrogen into the soil. Various herbs and "weeds" concentrate particular elements – for instance, heliotrope will flourish when copper becomes scarce, and is known to accumulate copper. Whether this is obtained from deep in the subsoil, or is in fact the result of a biological transmutation enacted by heliotrope in conjunction with its specific community of microorganisms and enzymes, is as yet unknown, but the fact is, it accumulates copper. In a biodiverse pasture, with a rich soil ecosystem and good humus levels, the transmutation of elements goes a long way towards providing a balance of nutrients to plants, and even though hundreds of tonnes of produce may leave a farm each year, taking nutrients with it, soils can continue to be productive for many years, despite no or only very low fertiliser inputs, as new elements are constantly being created from others.

There are limits however. Under current conditions, farmers have to export large amounts of produce to make a living, in contrast to European traditional organic farming of 150 years ago, whereby all farm wastes were conserved, and much of the production was retained to feed the extensive farm families. Only relatively small amounts were exported from the farm. Also, the European climate is much gentler and more conducive to no-input biological farming. In Australia, long drought periods depress biological activity and lower organic matter and humus levels. In practice, Australian BD farmers do generally have to import some non-water soluble fertilizers from time to time, albeit at considerably lower levels than do organic farmers, and vastly less than conventional farmers.

Soil Structure

Open, crumbly, friable soil structure is a fundamental aim of Biodynamics. Soil life (whose role is to turn organic matter into colloidal humus) functions best in a well structured, well aerated, well drained soil. It is soil life that creates well structured soil, through root activity, humus development and the creation of soil

aggregrates (grown crumbly lumps). The proper use of well made BD preparations is instrumental in the creation of well structured, humus rich soil. Without BD preparations (also the use of poor quality preparations or the poor application of good preparations) soil development is far slower, and more fertilizer inputs are required to compensate for the less developed soil life, humus levels and structure.

Where existing sub-soil compaction exists, deep ripping (as first developed by Alex Podolinsky in the 1950s) is used in semi-dry soils to crack the subsoil and relieve the compaction, allowing roots and soil biology to extend well into the sub-soil.

The ability of roots to search widely and deeply in a well structured, well drained, biologically active, humus rich soil, is a major factor in the ability of BD farmers to produce high yielding crops year after year with minimal or no inputs. It also explains the fact that BD crops stay green for many weeks longer than conventional crops in a dry spell, often producing a viable crop in a drought whilst conventional neighbours' crops fail.

Soil Cultivation

When soils have to be cultivated, the focus is on taking great care to disturb the soil structure as little as possible, and to avoid the creation of hardpans, or subsoil compaction. Soils should be slowly "broken" rather than cut. To this end, implements are chosen carefully: in general, tyned implements are preferred (such as the Rehabilitator plough[10], chisel ploughs, agro-ploughs, scarifiers etc.). Disc harrows or ploughs are acceptable if used with care in certain situations. Rotary hoes are very dangerous for soil structure, and require a

[10] See *Biodynamic Growing* No. 9, Dec. 2007, pp34-36

high level of care and understanding. They are generally best restricted to shallow "chip hoeing", to, for instance remove a dense grass mat before cultivation for a crop. Mouldboard ploughs can be used, but conventional mouldboards tend to create a hardpan, by cutting a "table top" under the soil. They are much better for the soil if a downward pointing tip is attached, to break the soil rather than cutting it. The Rehabilitator plough, made by Michael Fix (Victoria) is the state of the art Biodynamic plough, gently breaking and lifting soil, with low horsepower requirement.

Soils should never be overworked, but left in a rather rough state, only fining the top few centimetres if fine seeds are to be sown. Soil should never be worked too wet or too dry, and should always be worked slowly (no faster than a horse walks). Soil should never be "chucked", or dust created. Tractors should be of as low weight as practical for the particular farm needs. Even when caterpillar tracks or balloon tyres reduce the weight applied to the topsoil per square centimetre, this is illusory, as the overall weight still presses as a whole on the subsoil, and can cause compaction.

Green Manuring

Green manuring is an invaluable way of providing humus for subsequent crop growth, whether it be vegetables, grains, berries, or in orchards or vineyards. In Biodynamic green manuring, as in pasture composition, we aim to include a very wide range of species, with the leguminosae and graminaceae (grain) families predominating. Each plant species brings its own unique qualities to the mixture, its own associated community of microbes and fungi, its own root exudates, and associated enzymes. Each plant brings a different composition of elements and a different capacity to concentrate different elements, whether through biological transmutation or by the roots and associated soil life seeking out particular elements. One of the finest examples of Australian Demeter Biodynamics in Europe, Agrilatina Cooperative, Italy, uses up to 90 species in its summer green manures and up to 30 in its winter green manures.

Alex Podolinsky has suggested that there may well be a qualitative difference between an element contributed by one species and the same element contributed by another species, just as there is a qualitative difference between the C sharp played by a trumpet and an oboe in an orchestra. The richness of a very diverse green manure may contribute more to the soil and to humus in a qualitative sense than simply the sum of the elements it provides, just as an orchestra provides a richness and diversity of sound even when the same note is played by all instruments.

When the green manure is ready, it is cut up as finely as possible (best by a mulcher), and worked into the soil (best with a Rehabilitator plough, several times), where it undergoes in-situ composting, with the assistance of a prepared 500 spray. The following crop is planted or sown when the green manure has been broken down and converted into colloidal humus. The more diverse the green manure, the better balanced nutritionally will be the colloidal humus that results.

Weeds as Green Manure

Pioneered by Western Victorian Biodynamic farmer, Barry Edwards, this technique recognises that Nature will always try to bring balance into the soil. The ground is left to grow whatever wants to come, until the weeds, herbs and grasses reach their optimum development. While the plants are still green, they are incorporated in the soil, are broken down and converted into humus by the soil life. The subsequent crop always flourishes, as Nature has ensured that the wide array of plants that constituted the green manure would bring whatever elements were lacking in the soil. An additional benefit is that, as the weeds grew there to balance a deficiency, once that deficiency is rectified, they don't need to grow there again for some time.

Under this system, Barry Edwards only needs to apply 3kg of phosphorus (non water soluble) per hectare per crop (2 crops in five years) compared with the 12-20kg (water soluble) applied by conventional growers. His crop yields are generally comparable with his neighbours' conventional crops.

Biodynamic Compost

Is the perfect plant food, being 100% colloidal humus, and is an invaluable input in many situations, from home gardens to market gardens, orchards, berry farms, and dairy farms. It contains a wide variety of elements brought by the manure of grazing animals and the varied plant material used, and is a rich source of beneficial microbes.

We have here only considered factors involving the soil, air and sun. There is much evidence that plant growth and nutrition are also influenced by the moon, planets and zodiac star groupings. Some of these factors are employed to good effect by Biodynamic gardeners and farmers. However they are beyond the scope of this article.

The reason Biodynamics works so well is that every aspect of the method, based on scientific understanding, meticulous experiments and extensive field trials, is focussed on building and protecting the essential soil life, whose collective function in Nature is to convert organic matter and any free soluble elements into stable colloidal humus, which feeds plants as Nature intended, under the jurisdiction of the sun, not indiscriminately through the soil water. The Biodynamic preparations are the most powerful (and unique worldwide) stimulators of biological activity in the soil, and, when combined with associated biological agricultural practices, enable farmers and gardeners to produce food of the highest quality with absolutely minimal inputs.