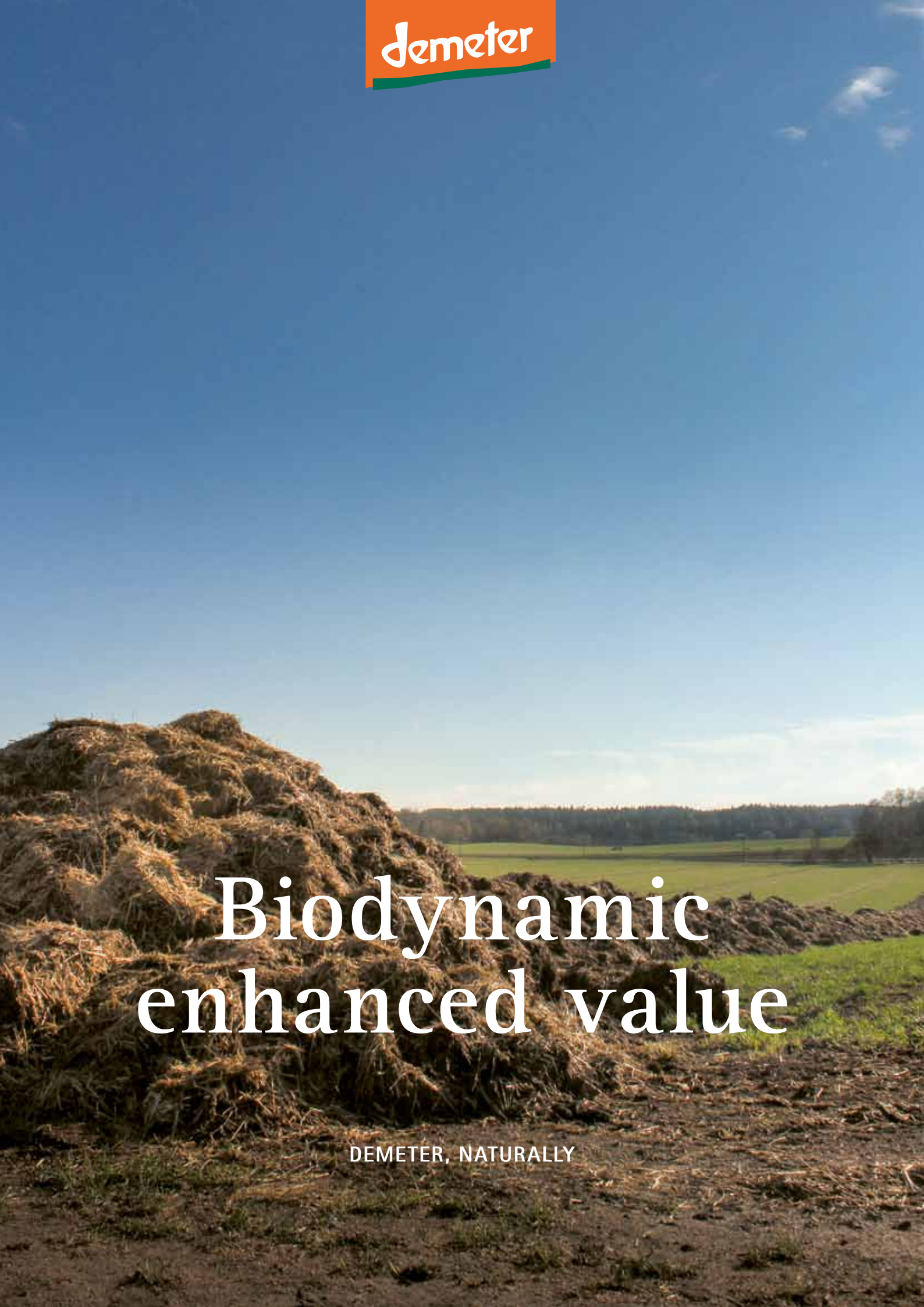


Biodynamic enhanced value

DEMETER, NATURALLY

Having access to good food is one of our most fundamental rights

Your health, and that of the earth. The wellbeing of humankind, of the soil and of the planet are bound together. Beginning with the soil, and ending with our digestion. But what does the food we eat actually contain? Does the soil contain sufficient nutrients for plant growth, does our food taste good, and how does it contribute to our health?

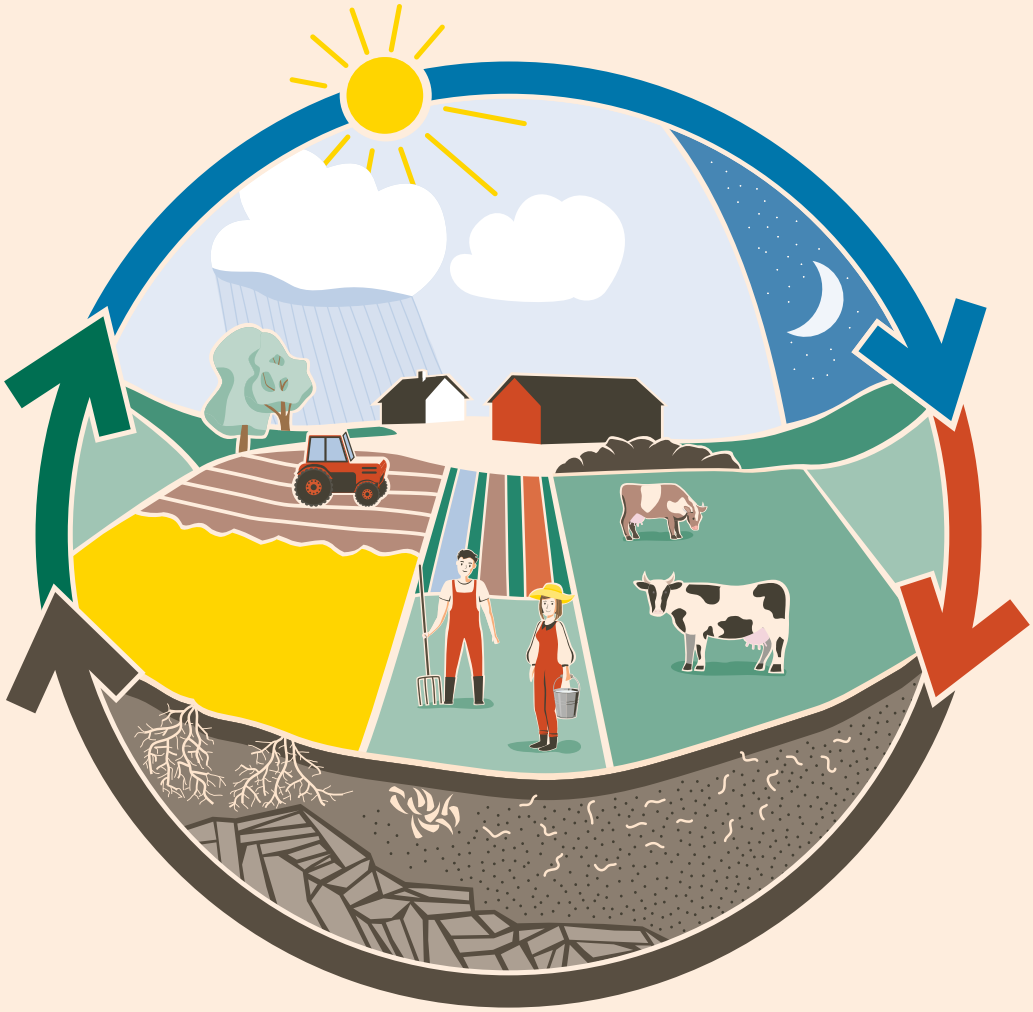
Today's large-scale food production increasingly prioritises quantity over quality, with volume apparently more important than nutrition or vitality. As a consequence we see depleted soils, toxins in the environment, and vegetables and grains poor in flavour and low in nutrients.

To improve the soil's fertility takes a very long time. Examining this calls for long-term field-scale trials if changes are to be ascertained with statistical certainty. Biodynamic agriculture has existed in Sweden since 1935. Research work began in 1958 through the Nordisk Forskningsring, continuing from 1986 under the direction of Artur Granstedt at the Stiftelsen Biodynamiska Forskningsinstitutet (SBFI). This booklet reproduces some of the results from long-term research in Ytterjärna, Sweden, along with Jens-Otto Andersen's research at the Biodynamisk Forskningsforening in Denmark. The SBFI has amongst other things examined how different forms of manuring and the use of the biodynamic preparations can influence soil fertility and crop quality. The various trials are described more fully at the Svenska Demeterförbundet's website www.demeter.se

The aim of biodynamic agriculture is to produce tasty and vital food, containing the nutrients we need in order for us to develop in the best way possible. And the route to this is a healthy soil. In addition to the measurable nutrient content are two further important aspects; the vitality and the flavour of the food. To state that biodynamic food tastes better may seem subjective, but it is a fact that many award-winning restaurants are major purchasers of biodynamic vegetables.

Farm organism and its cycles

A biodynamic farm is treated as a farm organism. It has its own individuality, all parts being needed in order to form the whole. The farm is driven by energy streaming from the sun, the various cycles, and its own biodiversity. Its own cycles and energy streams also relate to the greater ecosystem, and the farm's activities are influenced by weather, wind and water. The mineral, plant and animal realms are managed and cared for by human beings, and bound together in a coherent whole.



Photosynthesis binds solar energy into the crops. Soil nutrients, together with water and carbon dioxide build up the plant's physical form. A suitable crop rotation is important if the soil is not to become exhausted in the long run. Fodder for the farm's livestock constitutes a major part of what is grown. Leys with nitrogen-fixing legumes also contribute nutrients to the soil.

Of the plant and animal wares produced over the summer, a proportion leave the farm to be consumed. With this, a certain amount of soil nutrition is removed from the farm's fertility cycle, whilst a relationship is formed to the surrounding area. Leakage from composting and fields also leads to some loss of soil nutrients.

Plant nutrients and organic material are returned to the soil through the addition of composted manure, leys with nitrogen-fixing legumes and incorporation of crop residues. This organic mass stimulates the soil microlife which, together with stable nutrients in the soil's humus, constitute the basis for the coming year's production.

In the spring the returning warmth brings an increase in biological activity in the soil. Microorganisms work to release nutrients from the soil's humus reserves, whilst other nutrients are made available by weathering of the underlying bedrock. As the plants we grow become established, they extend their roots through the topsoil and into the subsoil, seeking out nutrients.

WHOLENESS AND THE FERTILE SOIL

The arable soil has slowly formed over thousands of years. The upper layers are comprised of a delicate blend of minerals from the weathered bedrock together with organic matter from decomposing plants and animals. Within this layer, humankind has built up an agricultural system driven by the streaming energy of the sun and maintained by its own labours.

An important starting point in biodynamic agriculture is the concept of the farm organism. This is a perspective which places all elements of the farm into a context. Each biodynamic farm is a unique individuality, where the constituent parts form the whole. Within a framework of organic recycling agriculture, the farmer works to strengthen the whole, which includes mineral, plant and animal.

Fertile soil

In biodynamic agriculture the soil is cared for and manured in such a way as to ensure good ecological balance and long-term fertility. Thus can the plants we grow have access to plentiful and varied nutrients, allowing them to develop optimally and be harvested fully ripe, well-flavoured and suitable for storage. Biodynamic preparations are used to enliven and strengthen life processes in both the soil and in the crops. The humus content of the soil, its content of organic matter, is of particular importance.

In an agricultural system of refined cycles where the long-term fertility of the soil is built up, healthy plants have access to a broad spectrum of nutrients, enabling us to receive food which is as nutritious as possible.

How does the soil's humus content increase?

A soil can quickly be depleted, whilst it takes a very long time to build up its fertility. Just how long it takes depends on a soil's characteristics. It has been shown that humus levels on a biodynamic farm can be increased over time. This can be achieved through the following measures; the stocking den-

sity should be in balance with the amount of fodder grown; manure from the farm's livestock should be composted with the biodynamic preparations added for maximum effectiveness; the biodynamic field sprays should be used; crop rotation should be practised, alternating fertility-building fodder crops and leys incorporating nitrogen-fixing legumes with fertility-depleting crops for human consumption.

Biodynamic foods have more vitality. Use of the biodynamic preparations balances the plant's development so that growth and ripening take place optimally.

What are the biodynamic preparations?

The purpose of the biodynamic preparations is to stimulate and regulate life processes in both soil and plant. They are made from medicinal plants and minerals, in connection with seasonal processes in nature. The six compost preparations of yarrow, dandelion, chamomile, nettle, oak bark and valerian, four of them having undergone a process of decay in various animal organs, are added to the manure or compost heap when its construction is complete, in order to influence the qualities of the compost as it matures. The two field sprays, of cow manure and quartz respectively, undergo preparation in a buried cow's horn, and are activated by stirring into water which is then sprayed out, the first in conjunction with tillage operations and the latter to support the ripening process.

Four times more earthworm channels per unit area

WORMS, MICROLIFE AND DEEP ROOTS

Soil organisms are important for fertility and for biodiversity in the soil. Manure is an excellent food for earthworms, whose numbers increase significantly when it is available.

The finest humus results from the digestive processes of the earthworm, and the soil aggregates thus created become stable humus which gives long-term fertility.

Soil activity in field experiments was consistently better when manure was used, under both organic and biodynamic cultivation. The number of earthworm tunnels per unit area was four times higher compared with conventional cultivation.

The trials also show that the use of leys and composted manure, treated with the biodynamic preparations, is important not only for increasing and maintaining humus levels, but also for storing carbon in the soil.

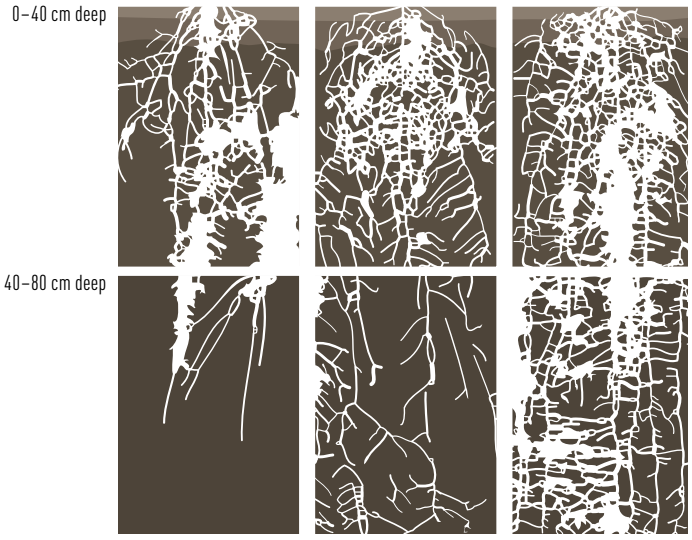
Also apparent is that the humus content of deeper soil layers increases where manure is applied. This can probably be explained by stronger root development which leaves more organic residues deeper in the soil after harvest, building up the humus content even in the subsoil.

Another benefit is that the soil becomes more water-retentive. More extensive root systems in turn affect biological activity as the roots secrete exudates, energy-rich products of photosynthesis, which feed microfauna around the roots.

The higher humus content and enhanced microlife fostered by biodynamic methods are important for making nutrients in the soil available to plants. Earlier European research also shows strongly increased humus content and biological activity in biodynamic soils.

Carbon sequestration is **greater** with biodynamic agriculture, showing a **20%** increase over 29 years

Impact of biodynamic preparations on root development *
Extent of roots in trial with French beans. From left to right: fresh manure, composted manure, composted manure with biodynamic preparations. First line at a depth of 0–40 cm och second line 40–80 cm.



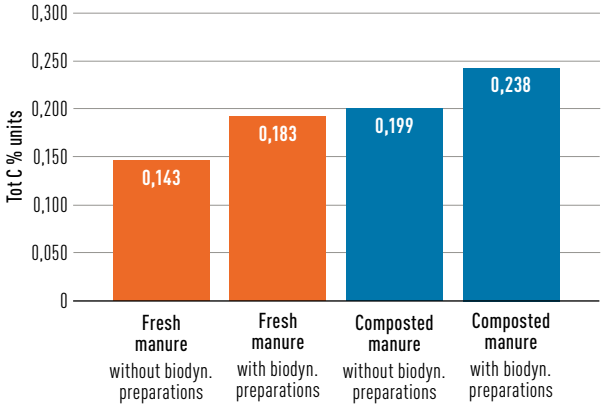
ENVIRONMENT, CARBON SINK AND REDUCED NUTRIENT LEACHING

The earth's atmosphere contains "greenhouse" gases which maintain climates conducive to life. The changes in climate currently taking place are caused primarily by our altering the amounts of these gases at an ever increasing rate, partly through the burning of fossil fuels, but also as an effect of our food production.

Modern intensive agriculture causes a large turnover in the soil, and humus is depleted without it being replaced by new organic material. Carbon is released from the soil into the environment. Organic and biodynamic recycling agriculture can act as a carbon sink. With increasing humus content, more carbon is stored in the soil, meaning less carbon dioxide in the atmosphere.

In the long-term field experiments those plots which received composted manure, with the biodynamic preparations added, showed a soil carbon increase of 20% over 29 years. International research has showed similar results. Follow-up trials in Sweden showed humus content increasing by 9% over 9 years under biodynamic cultivation, whilst conventional cultivation showed no change whatsoever.

Change in humus content (tot C) in long-term fertility trial at Skilleby 1991–2005 *
In the long-term trial at Skilleby 1991–2005 the change in humus content shows as total carbon (tot C). This supports the earlier results that soil carbon content increases with biodynamic agriculture.



Less nutrient leaching with biodynamic cultivation

The "development" from self-contained recycling farms to specialised agriculture with either monoculture of arable crops or one-sided livestock production, both dependant on external inputs, has led to major environmental problems, of which over-fertilisation of the Baltic Sea is one. Agriculture accounts for approximately half of all nitrogen and phosphorus leakage into the Baltic's unique brackish water system, causing eutrophication, algal blooming, changes in the marine ecosystem, elimination of important species and lack of oxygen, causing the death of large areas of seabed.

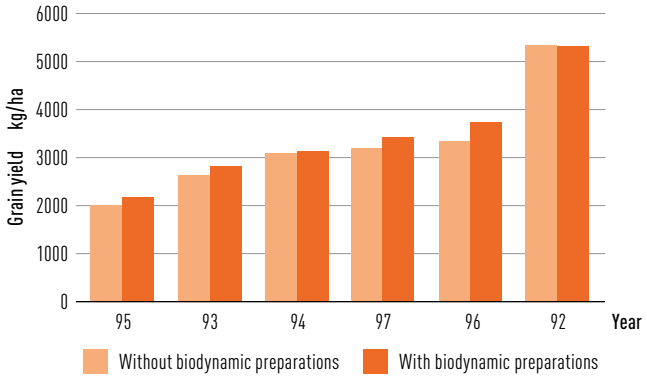
Specialised livestock farms, with their surplus of manure, are major sources of nutrient leaching, while purely arable farms show little leakage but are instead dependant on livestock farms for manure, or else use artificial fertilisers. Nutrient balances calculated for conventional stockless arable farms show that more trace elements are lost from the soil than are added to it. In time therefore the nutritional content of vegetable crops similarly declines. Nutrient balances for conventional livestock farms show a surplus of nutrients such as nitrogen and phosphorus, and such farms are thus a burden on the environment.

Biodynamic agriculture maintains levels of available plant nutrients in the soil.

The biodynamic preparations have a **balancing effect** on quantity, whilst retaining quality

Research on the good mineral soil of Skilleby Farm shows that the limited net losses occurring in biodynamic agriculture do not lead to depleted levels of plant nutrients in the soil. The biodynamic approach, with crop rotation including leys along with the balance maintained between manure and fodder availability, leads to soil nutrients being present in a closed cycle within the farm to a greater degree than on a specialised, one-sided livestock enterprise.

Effect of the preparations in biodynamic agriculture *
Autumn wheat yields 1992–1997. Trial plots with composted manure, with biodynamic preparations and without. The graph shows both years with lower than normal yields, where yields increased with preparation use, and years with higher than normal yields, when preparation use lowered the yields somewhat.



YIELD AND QUALITY

We often hear that food supply in the future will be insufficient for a growing population. But are higher yields all that we are looking for? Wheat has become ever more highly bred, with the grains becoming larger, and a corresponding increase in carbohydrate content, whilst nutrient content has remained unchanged.

Crop yields vary year by year, depending on the weather during the growing season. Comparisons between results from trials with different growing methods refer therefore to the same conditions with regard to year and place.

Research has shown that the biodynamic preparations optimise yields, whilst maintaining as high quality as possible. In years with very favourable conditions and high yields, those trial plots treated with the biodynamic preparations showed somewhat lower yields than organic and conventional plots, but maintained consistently high quality nevertheless. The opposite has been seen in years when yields were normal or lower than normal, with the biodynamic plots yielding better than those treated organically, but without the use of the biodynamic

Wheat kernels grown biodynamically contained **larger quantities**

preparations. These results have been recorded over many years and from several different places.

It is possible to achieve yields as high with biodynamic methods as with conventional, but first soil fertility has to be built up. In trials in Järna, yields from crops which had received organic manure were lower for the first eight years. Later trials showed a difference in total yield between biodynamic and conventional of less than 10%. One trial with spring wheat grown biodynamically yielded just 1.5% – 4% lower. Trials with autumn wheat on the other hand showed use of the biodynamic preparations giving a yield 4% – 5% higher five years out of six.

Studies of potatoes showed a significantly lower yield, grown biodynamically, but when losses during storage were taken into account the difference became negligible. The superior keeping qualities make up for the lower yield.

What is good quality in food?

When we look at food quality we touch on a whole range of different factors. For one thing there is the question as to how food quality can be measured.

Results from trials concerning yields, storability and nutritional content can be examined. With regard to nutrients in food we can look at the content of minerals, fats, amino acids, antioxidants, bioactive substances, vitamins and fibre. We can also look at undesirable substances such as residues of toxins and heavy metals.

But a very important factor is vitality, actual life force. This has a bearing on the resilience of a food, how it is able to withstand stress and how it is able to maintain it's natural life-cycle functions. In short, how alive it is.

We need to take in trace elements and minerals, important for most of the body's functions, through the food we eat. These have to be taken in from nature as our bodies cannot manufacture them, but they are needed daily for the constant renewal of the body's cells. Mineral deficiencies can cause various illnesses. Plants too need minerals and trace elements, which must therefore be available in the soil.

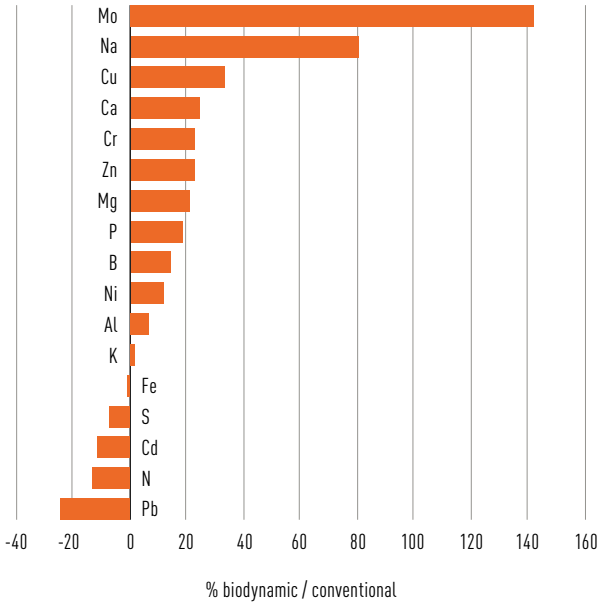
The quality of agricultural produce depends in part on its nutrient content. Different soils have

# of minerals than conventionally grown wheat

varying capacities for supplying plants with minerals depending on underlying geology.

Trials from 2006 showed that with biodynamic methods, as opposed to conventional, the following elements occurred in higher quantities: molybdenum (Mo), sodium (Na), copper (Cu), calcium (Ca), chromium (Cr), zinc (Zn), magnesium (Mg), phosphorus (P), boron (B), nickel (Ni), aluminium (Al) and potassium (K).

Mineral content in 6 wheat trials from biodynamic recycling agriculture and conventional agriculture *
The graph shows the difference between conventionally and biodynamically grown wheat. The 0-line indicates the levels in the conventional wheat and the horizontal bars show how much more or less (in %) of each mineral the biodynamic wheat contained.



The increase in phosphorus is worth remarking on, as it is nowadays scarce in agricultural soils, and usually in a difficult to access form. Supplementing it via artificial fertiliser is problematic as it leaches out into watercourses. The research also showed that biodynamically grown cereals contained lower levels of the poisonous heavy metals cadmium (Cd) and lead (Pb). Biodynamic wheat kernels contained lower levels of nitrogen (N) and sulphur (S).

What are proteins and essential amino acids?

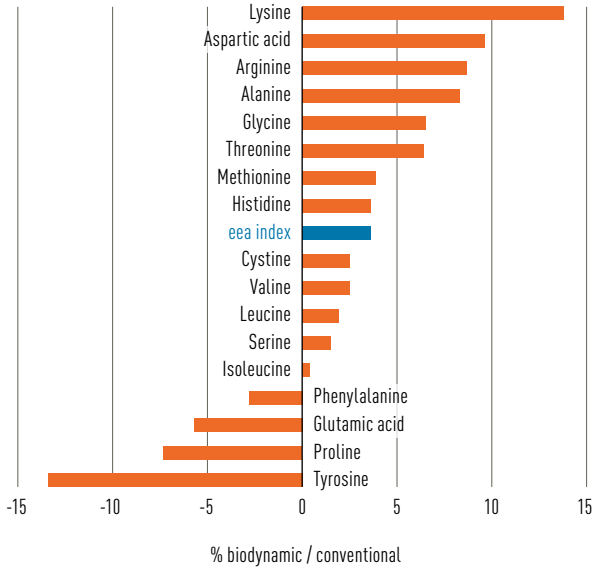
Cereals are an important source of protein from the plant realm. But the nutritional value of the protein is determined by its essential amino acid content.

Proteins contain the base element nitrogen, a fundamental building block and carrier of life in the living cell. Proteins consist of around 20 amino acids, 9 of which are essential. These are crucial for

The percentage of essential amino acids was **3.5%** higher in biodynamically grown cereals

life, and we need to ingest them with food as our bodies are unable to produce them. High levels of amino acids such as lysine, methionine and others are indicative that a protein is of high nutritional value.

Amino acids as % of crude protein *
Comparison of the amount of essential amino acids in conventional and biodynamic wheat. The 0-line indicates levels in the conventional wheat. The horizontal bars show levels in the biodynamic wheat as % of the conventional. The graph shows higher levels of 8 of the 9 essential amino acids in the biodynamic wheat.



Limited obtainability of easily available nitrogen in cereal production, which is the case where manure, and especially composted manure, is used leads to the formation of more high quality protein. The use of artificial fertilisers, which make nitrogen more easily available, lead to more gluten being formed. Research showed a 3.5% higher essential amino acid content in biodynamically grown cereals than in conventionally grown. Eight of the nine essential amino acids were present in higher quantities.

Vitamin C in apple juice

Crops grown for good quality also need to be processed carefully if nutritional values are not to be lost. A healthy apple contains 10 mg vitamin C per 100 g juice. Pressed apple juice is pasteurised by heating, and the more carefully this process is carried out the higher the vitamin C content of the finished product.

The Danish researcher Jens-Otto Andersen has studied the quality of biodynamic apple juice, in comparison with conventional and organic juices.

The biodynamic juices show the **highest values** in comprehensive trials

One of the conventional products tested contained more vitamin C than actual apple juice, as artificial vitamin C had been added after pasteurisation. This is permitted in conventional products, but not in organic or biodynamic juices.

Ignoring products with added vitamin C, biodynamic juices scored highest in the tests. This shows that the juice, which had a good vitamin C content from the outset, had been pasteurised gently. The biodynamic products are treated as carefully as possible during processing in order that nutrition and vitality be retained.

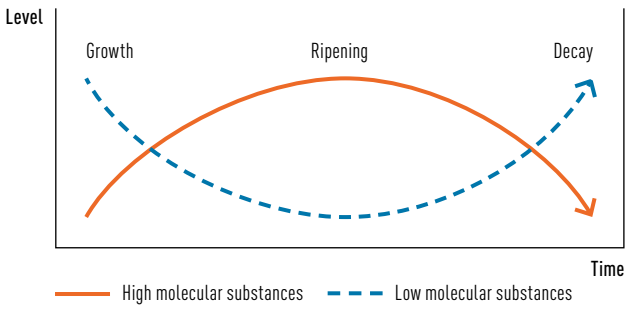
In earlier trials with potatoes in Järna, also examining vitamin C content, biodynamic potatoes consistently contained higher amounts than were found in conventionally grown potatoes.

And vitality

In biodynamic research it is important that plants are studied throughout their life cycle in order to understand their quality characteristics. An organism grows, reproduces, and dies. In the beginning of the growth cycle low molecular substances, such as various salts and nitrate, dominate, being taken up by the plant from moisture in the soil. During ripening, more complex associations of higher molecular weight dominate. These have a great effect on nutritional value, and are evident in the form of vitamins, antioxidants, higher proteins and sugars.

A plant which is vigorous and vital can defend itself against external attack. Vitality is the living organism's ability to withstand stress, and to resist degradation by microorganisms. But it also gives us increased vitality when we eat the food.

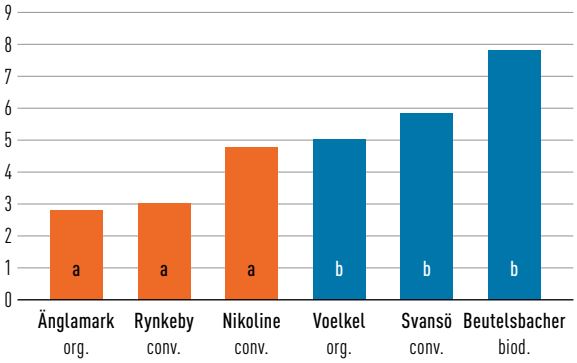
Plant growth and decay *
The graph shows various molecular substances during growth. Low molecular substances dominate at the beginning. During ripening more complex associations of higher molecular weight dominate.



Biodynamic research has led to the development of new imaging methods for measuring quality. The most known of these is copper chloride crystallisation. A small amount of juice is mixed with copper chloride, and is then allowed to crystallise on a glass plate, with the resulting image indicating the vitality of the crop or product. Another method is capillary dynamolysis, where plant juice is absorbed by a disc or cylinder of filter paper, producing, with the aid of silver nitrate solution, an image.

Danish research examined whether there was any difference between freshly pressed products and pasteurised, filtered and concentrated products. In the tests the biodynamic juice, along with two other pressed and filtered juices (as opposed to the conventional products made from filtered concentrate) showed the highest vitamin C content, best flavour and crystallisation images. Apple juices of biodynamic origin received the highest final scores and showed the best values in these comprehensive tests examining the vitality and nutritiousness of products.

Comprehensive test scores †
Average values from flavour test of 3 conventional and 3 organic / biodynamic products. The apple juice of biodynamic origin was the best tasting product.



CONCLUSION AND SUMMARY

Many factors combine to form the farm organism which distinguishes a biodynamic farm. The biodynamic preparations act together with cultivation measures to create a living environment which is as diverse as possible. And together with the people who run the farm a complex web of life develops, an agricultural individuality, which imbues the produce of the farm with a special quality. And the biodynamic produce is then treated in accordance with its value as carrier of life and health, this being taken into consideration at every stage, from how the soil is cared for to how the product is grown and finally processed.

This booklet is a guide to the results of the various experiments conducted in Sweden and Denmark, illustrating the enhanced value that biodynamic agriculture has to offer.

MORE INFORMATION

Stiftelsen Biodynamiska Forskningsinstitutet
www.sbfi.se

Svenska Biodynamiska Föreningen
www.biodynamisk.se

Skillebyholm Biodynamiskt Utbildningscenter
www.skillebyholm.com

Biodynamisk Forskningsforening i Danmark
www.biodynamiskforskning.dk

Graphs * Artur Granstedt, Stiftelsen Biodynamiska Forskningsinstitutet, www.sbfi.se; † Jens Otto Andersen, Biodynamisk Forskningsforening i Danmark, www.vitalitet.org

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