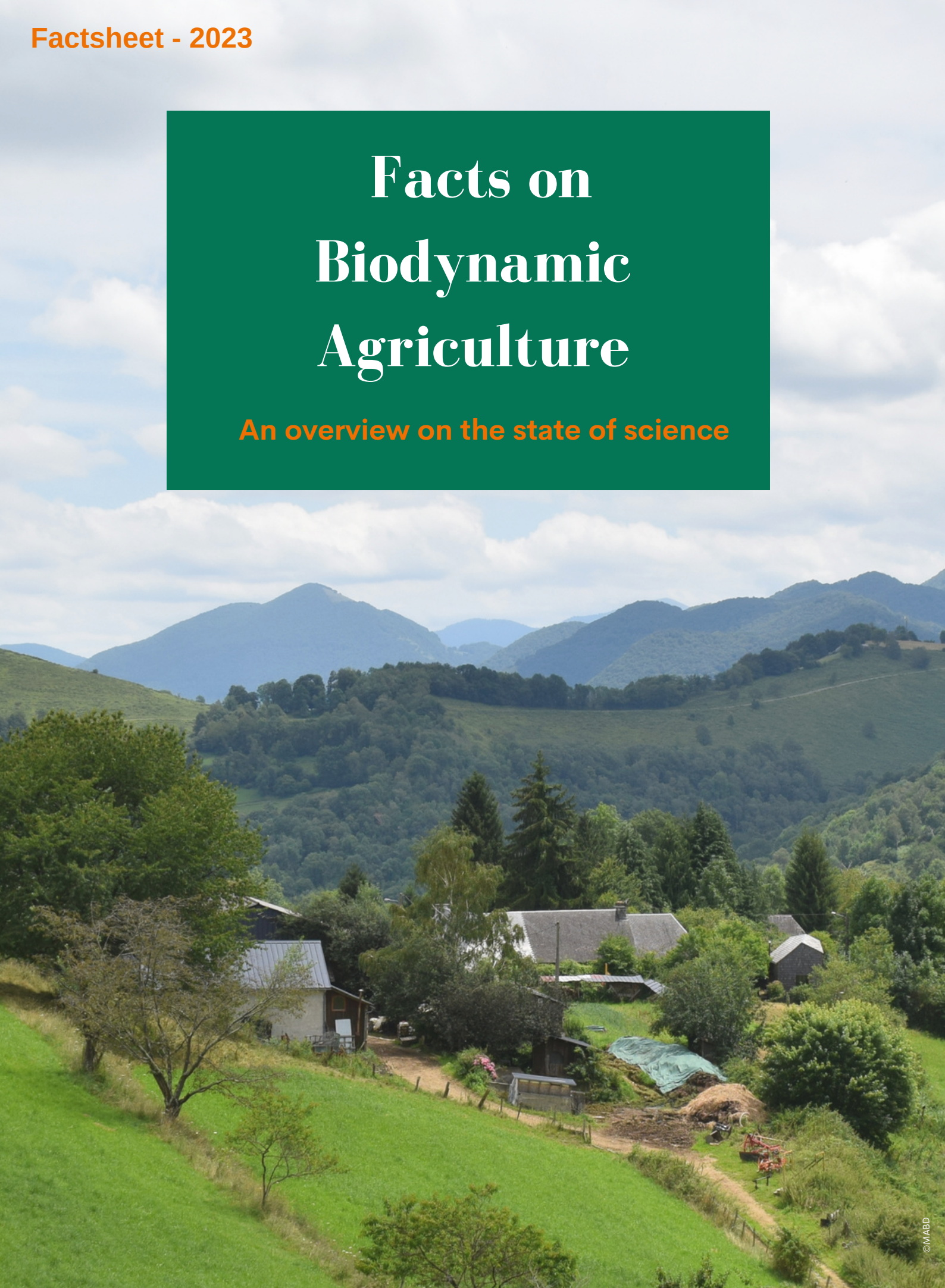
Factsheet - 2023

Facts on Biodynamic Agriculture

An overview on the state of science



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Goetheanum Agriculture

Biodynamie Recherche

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FORSCHUNGSRING

This booklet is a collective work from the Biodynamic Federation Demeter International, Biodynamie Recherche, Demeter Germany, the Forschungsring and the Agriculture section in the Goetheanum.

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The information presented here summarises the current state of knowledge on biodynamic agriculture, which is available in two systematic reviews of scientific literature published to date (Brock et al., 2019 and Santoni et al., 2022), including a meta-analysis of soil ecological properties (Christel et al., 2021), as well as a synthesis paper on the potential and challenges of biodynamic farming as a resource for sustainability transformation (Rigolot & Quantin, 2022).

SUMMARY

BIODYNAMIC AGRICULTURE

Biodynamics is a holistic agricultural system. Its origin comes from a series of lectures given by Rudolf Steiner in 1924 published later under the title, ‘Agriculture Course’. These lectures were the response to a concerned group of farmers who perceived negative impacts on farming, mainly due to a monoculture approach and the use of chemical fertilisers. Farmers and gardeners developed the first indications to transform agriculture into a regenerative activity by putting them into practice and observing the results. This led further to the creation of the Demeter brand, with its own standards to certify products from biodynamic farming. The biodynamic approach can be described by the following principles, which have recently been formulated by the Biodynamic Federation Demeter International (BFDI):

- Regeneration – sustainability is not enough.
- Integrating the well-being of nature and humans – we are part of the picture.
- Creating a living context where humans, animals and plants can thrive and develop.
- Including animals in a way that respects their well-being while producing nutrient-dense food, nourishing the soil, and protecting wildlife.
- Agriculture is contextual regarding ecology, landscape, and culture.
- Ecological responsibility – Caring for resources, including packaging and transport.
- Social responsibility – Supporting community development and a cooperative approach throughout the supply chain.

Biodynamic farming is repeatedly accused of being esoteric and unscientific, mainly due to its cultural approach, which is not always fully comprehensible from a modern science-based perspective. However, there is scientific evidence for the effects of biodynamic management that acknowledge the great potential of biodynamic farming to contribute to the sustainable development of food and farming systems.

SOIL QUALITY

Biodynamic agriculture is the farming system with the most favourable effect on soil quality, followed by organic and conventional agriculture. As Christel et al. (2021) found in a meta-analysis of approximately one hundred articles, 52% of microbial indicators were higher in biodynamic farming when compared with organic farming.

ENVIRONMENTAL SUSTAINABILITY

Biodynamic agriculture favours circularity on farms, using animal manure and green manure produced on the farm instead of external organic fertilisers. Therefore, biodynamic farming tends to be more ecologically efficient since external inputs are lower than for other production systems to produce the same quantity (organic, conventional) (Santoni et al., 2022).

BIODIVERSITY

Until now, scientific studies of biodynamic effects on biodiversity have been rare. However, biodynamic principles favour structural characteristics of farms and farming measures that are known to promote the overall biodiversity of agroecosystems, such as vegetation buffer strips, riparian corridors, and hedgerows that provide shelter to pollinators and natural predators. (Santoni et al., 2022).

For more information : https://www.sektion-landwirtschaft.org/en/research/basics

FOOD QUALITY

Biodynamic farming always strives for the best food quality. In fact, positive effects of biodynamic management on food quality have been reported. From the inventory of Brock et al., 17 out of 21 studies comparing food quality show a positive effect on food quality under biodynamic management. In several cases, specific effects of the biodynamic preparations on food quality could be observed.

BIODYNAMIC PREPARATIONS

Initial results suggest that preparation 500 may have the potential to stimulate plant growth (Santoni et al., 2022). However, studies on the effects of biodynamic preparations are few and far between, and some results need to be revised.

SOIL QUALITY

Biodynamic agriculture considers the soil to be a habitat for numerous living organisms that provide a wide range of ecosystem services, including soil fertility and maintaining healthy soil, which is vital to meeting the needs of these microbial populations. In this sense, biodynamic management appears to have the potential to improve the soil microbiome, as Christel et al. (2021) found in a meta-analysis of approximately one hundred articles. This study found that 52% of microbial indicators were higher in biodynamic farming, even when compared with organic farming. Biodynamic agriculture is the farming system with the most favourable effect on soil quality, followed by organic and conventional agriculture.

Various parameters are commonly studied to assess soil quality. First and foremost are the macrofauna (earthworms, ants, spiders, etc.), which modify the soil physically by transforming and recycling organic matter. Their activity helps maintain soil porosity and structural stability. These organisms act in conjunction with mesofauna (e.g., arthropods) and microfauna, which regulate the chemical and biological properties of the soil. Finally, microorganisms (bacteria and fungi) are crucial in regulating soil life. They participate in the recycling of elements and influence the bioavailability of nutrients for plants whilst regulating soil health (Christel et al., 2021). All these biological functions ultimately determine the agronomic properties of soils. Research results show that soil microorganisms are impacted by production systems.

In most studies, soil fertility indicators are more positive under biodynamic than non-biodynamic cultivation. Higher soil organic matter reserves, better soil structure, increased microbial activity, and improved organic matter renewal can all be observed in these studies (Brock et al., 2019).

Soil organic matter (SOM)[1] is recognised as a critical factor in soil fertility and a wide range of soil functions. Higher levels of soil organic matter under biodynamic farming compared to all non-biodynamic treatments were observed in the DOK trial[2].

The most robust results relate to the abundance, diversity, and functions of microorganisms. In a large-scale comparison of soils from conventionally, organically, and biodynamically cultivated vineyards, a significantly higher functional diversification of microorganism communities and a much higher number of interactions between bacteria and fungi in biodynamic soils were observed (Christel et al., 2021).

The differences between biodynamic and organic soils still need to be determined, but the specific relationship of care between biodynamic farmers and their soil could play a role. Biodynamics thus gives rise to an original worldview[3] (Rigolot and Quantin, 2022).

[1] Soil organic matter (SOM): Soil organic matter is any material produced originally by living organisms (plant or animal) that is returned to the soil through the decomposition process. For practical purposes, organic matter may be divided into aboveground and belowground fractions. Aboveground organic matter comprises plant and animal residues; belowground organic matter consists of living soil fauna and microflora, partially decomposed plant and animal residues, and humic substances. The C:N ratio is also used to indicate the type of material and ease of decomposition. Hard woody materials with a high C:N ratio are more resilient than soft leafy materials with a low C:N ratio. Although soil organic matter can be partitioned conveniently into different fractions, these do not represent static end products. Instead, the amounts present reflect a dynamic equilibrium. For example, organic matter existing on the soil surface as raw plant residues helps protect the soil from the effect of rainfall, wind, and sun, whereas the stable organic fraction (humus) absorbs and holds nutrients in a plant-available form (fao.org).

[2]The DOC trial is a long-term field trial. In Switzerland since 1978, it has been used to compare three different cropping systems - BioDynamic (D), Organic-Biological (O) and Conventional (C) - for field crops such as wheat, potatoes, maize and soya. Crop rotation, tillage and choice of varieties are identical. The farming systems in the trial differ in terms of fertilisation and plant protection (fibl.org).

[3] In philosophy and social psychology, “worldview” refers to the set of metaphysical, physical and social representations that guide human action.

ENVIRONMENTAL SUSTAINABILITY

The agri-food sector is one of the most significant contributors to environmental impact in resource depletion, soil degradation, emissions, and waste production. Aware of these challenges, biodynamic agriculture aims to achieve balance by favouring circularity on farms and using animal and green manure produced on the farm, instead of external organic fertilisers. To this end, biodynamic specifications require including the animal element in the farming system to avoid importing organic inputs and resulting nutrient imbalances. Biodynamic management seems to therefore be more ecologically efficient since external inputs are lower than for conventional production systems to produce the same quantity. This result has been proven for various crops, except for biodynamic cultivation in energy-intensive greenhouses (Santoni et al., 2022).

Biodynamic agriculture and other forms of organic farming have several principles in common, such as crop rotation, mixed and intercropping farming, plant cover crops, low or no tillage, the use of green manure and compost, and pest control by biological, cultural, mechanical, and physical means, rather than by chemical ones.

These characteristics make the biodynamic system more sustainable and resilient, especially towards climate change. One study showed that the amplitude of plant responses to climatic threats was higher in biodynamic than in conventional management (Rigolot and Quantin, 2022). The same stood true for seasonal trends and pathogens attacks. This was associated with a higher expression of silencing and immunity genes[4], as well as higher anti-oxidative and antifungal secondary metabolite[5] levels. This suggests that the sustainability of biodynamic practices most likely relies on fine molecular regulations (Soustre-Gacougnolle et al., 2018).

It is important to always consider biodynamic farming as a complement to other forms of agriculture.

Regarding the social and economic aspects of sustainability, the limited number of studies makes it difficult to draw any conclusions. However, initial findings show that biodynamic farmers are keen to exchange ideas with each other and with scientists. Furthermore, biodynamic farmers have a specific type of relationship with their plants and animals, which falls under the ethic of care[6](Foyer et al. 2020).

[4] Gene silencing is the consequence of accidentally triggering the plant's adaptive defence mechanism against viruses and transposable elements. This recently discovered mechanism, although mechanistically different, has a number of parallels with the immune system of mammals.
[5] Secondary metabolism (also called specialized metabolism) is a term for pathways and small molecule products of metabolism that are involved in ecological interactions, but are not absolutely required for the survival of the organism.
[6] The concept of care was developed in the field of nursing by Jane Watson in 1998. Philosopher Milton Mayeroff defines this notion as "the activity of helping another person to grow and actualize himself, a process, a way of relating to another that promotes his development." Foyer J. et al, 2020, a French sociologist, took up this notion of care to describe the relationship between biodynamic winegrowers and their vineyards.

BIODIVERSITY

Biodynamic farming practices promote the overall biodiversity of agroecosystems. Biodynamic farms generally maintain vegetation buffer strips, riparian corridors, and hedgerows, which provide shelter for pollinators and natural predators (Santoni et al., 2022). Demeter Standards specifications require that 10% of the farm's total surface area be dedicated to biodiversity care, which includes elements for the maintenance of rare or endangered plant and animal species, and the creation of optimal conditions for insects, birds, and all forms of life in general, including soil micro-organisms. Impact studies on biodiversity often do not focus specifically on biodynamic management, but they do show that habitat protection measures have a positive impact on the abundance of species. This is what this meta-analysis of organic farming demonstrates (Stein-Bachinger et al. 2020).

Soil is a veritable ecosystem, harbouring a wealth of biodiversity. One hectare of soil can contain up to 15 tonnes of living organisms, or 1.5 kg of life per square metre (Christel et al., 2022). Large and small organisms play a vital role in the soil's functioning, influencing its physical, chemical, and biological properties.

Mäder et al. (2002) measured that biomass and abundance of earthworms were higher by a factor of 1.3 to 3.2 in organic and biodynamic plots compared with conventional ones. The average activity density of carabids, staphylinids, and spiders in the organic and biodynamic plots were almost twice that of the conventional plots.

Healthy ecosystems are characterised by high species diversity. The DOK trial shows that organic and biodynamic farming allows for the development of relatively diverse weed flora. In organically and biodynamically managed wheat plots, nine to eleven weed species were found, with only one species found in conventional plots. This result was clarified by Rotchés-Ribalta et al. (2017), who demonstrated that the seeds contained in the soil were more numerous in biodynamic soils than in other systems.

The improvement of biological activity and biodiversity above and below ground in the initial stages of food webs in the DOK trial is likely to positively contribute towards developing higher food web levels, including those involving birds and larger animals.

FOOD QUALITY

Biodynamic farming always strives for the best food quality. Out of 21 studies on nutritional quality comparison (from the inventory of Brock et al., 2019), 17 show a positive effect on food produced with biodynamic farming. In several cases, it's possible to link high nutritional quality of food and the use of biodynamic preparation. Although not enough studies have been conducted, initial conclusions indicate a tendency that polyphenol[7] and antioxidant[8] content in food is more elevated in biodynamic products.

It has been shown that organically grown products are nutritionally richer than their conventional counterparts. Nutritional properties, particularly the content of phenolic compounds, flavonoids[9], and antioxidant activity, are significantly higher in organically grown strawberries, mangoes, and grapes than in conventional produce (Santoni et al., 2022).

However, food quality is not just a question of the nutritional value of foods but also the result of how the soil microbiome interacts with plants, animals, and humans. Indeed, the One Health concept[10] suggests a link between human, animal, and environmental health. Therefore, the One Health approach could support the idea that biodynamic products are healthier (Santoni et al., 2022).

Regarding the number of existing studies, wine is the most common product in scientific literature on food quality. This can be explained by the fact that this product has always been linked to quality questions. Many studies have argued that organic and biodynamic viticulture has little influence on grape composition. However, organic and biodynamic juices tend to have higher levels of bioactive compounds[11] than their conventional counterparts. It is possible to differentiate between organic, biodynamic, and conventional red grape juices by measuring volatile organic compounds using mass spectrometry. These studies have revealed that biodynamic and organic juices have similar quality characteristics (Brock, 2021).

Studies on lettuce, apples and beet showed a higher polyphenol content. Lettuce and beet also show higher antioxidant levels, as do biodynamically grown chicory, mango, and Batavia (Brock et al., 2019).

Few studies have yet to be carried out on products of animal origin. However, several studies show that milk from biodynamic production is more favorable than from non-biodynamic systems (Brock, 2021)

[7] Polyphenols are sought-after secondary compounds in foods that enhance the nutritional value of products.
[8] Slows or prevents the oxidation process.
[9] Flavonoids are secondary plant metabolites. They form a class of polyphenolic compounds ubiquitous in plants (including vegetables and cereals). In particular, they are pigments involved in petal and fruit coloration.
[10] Living organisms and ecosystems are interconnected, and the health of some depends on that of others. "One Health" takes account of these complex links in a global approach to health issues. This includes the health of animals, plants and human beings, as well as environmental disturbances generated by human activity.
[11] "Bioactive compounds" are extranutritional constituents that typically occur in small quantities in foods. They are being intensively studied to evaluate their effects on health. The impetus sparking this scientific inquiry was the result of many epidemiologic studies that have shown protective effects of plant-based diets on cardiovascular disease (CVD) and cancer. Many bioactive compounds have been discovered.

BIODYNAMIC PREPARATIONS

Biodynamic preparations are a key feature that differentiates biodynamic agriculture from organic farming. These must be added as crop inputs and are numbered from 500 to 507. The two compulsory minimums for Demeter certification are 500, (horn manure preparation made using cow manure) and 501 (horn silica preparation made from ground quartz). As their names suggest, both are placed inside horns and buried for six months. Studies on the effects of biodynamic preparations are few and far between, and results sometimes need to be revised. However, initial results suggest that preparation 500 may have the potential to stimulate plant growth (Spaccini, 2012). This stimulation could come from the prolonged interaction between cow horns and faecal matter, which would improve the proteolytic decomposition process[12](Zanardo, 2020).

Studies on cumin, soybeans and rice have assessed the differences in yield between unfertilised and fertilised conditions. These studies concluded that yields, root length, and weight increase with the previously mentioned preparations. Other crops, such as lettuce and chilli, showed no difference in yield (Brock et al., 2019).

Several studies have observed positive effects of the preparations on soil parameters that can be can be related to the observed effects of preparations on plant growth. It is mainly the biochemical and microbial characteristics that these preparations have an effect on.

More details on preparation 500: Factsheet Horn Manure.

[12] Proteolysis is the breakdown of proteins into smaller polypeptides or amino acids.

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TO GO ONE STEP FURTHER...

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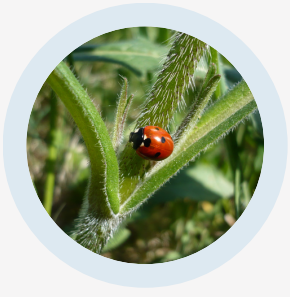

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The Biodynamic Federation Demeter International is the only agricultural association that has built up a network of individual certification bodies for biodynamic farmers worldwide. Today, they are a global community of farmers, winemakers, gardeners, beekeepers, researchers, advisors, trainers, certifiers, processors and traders to name a few. Find more information at : demeter.net

The aim of the Biodynamie Recherche association is to promote respect for and protection of the environment through biodynamic agriculture. It carries out scientific monitoring of work and publications in biodynamic agriculture at international level. It produces summaries, translations and articles which are made available to the French-speaking public on its website and in specialist journals. Find more information at : biodynamie-recherche.org

Demeter is a private certification body for biodynamically produced food, cosmetics and textiles - complementary to the official organic regulations. Their specifications have been developed over the decades to become one of the most demanding. Find more information at : demeter.de

The Forschungring was founded in 1946 as the successor to the Versuchsrings of Anthroposophical Farmers. In the early years it was the umbrella organisation of the biodynamic movement. Today it is the central research institute for biodynamic and general ecological questions at the centre of a worldwide and growing biodynamic movement. Find more information at : forschungsring.de

Through its contacts with people active in the biodynamic movement around the world, the agriculture section encounters many questions, ideas and challenges. Together with their partners, they work on these themes in various international projects and events. In this way, they create spaces in which questions and challenges can be transformed into sources of inspiration for those active in biodynamic agriculture and the food sector. Find more information at : sektion-landwirtschaft.org