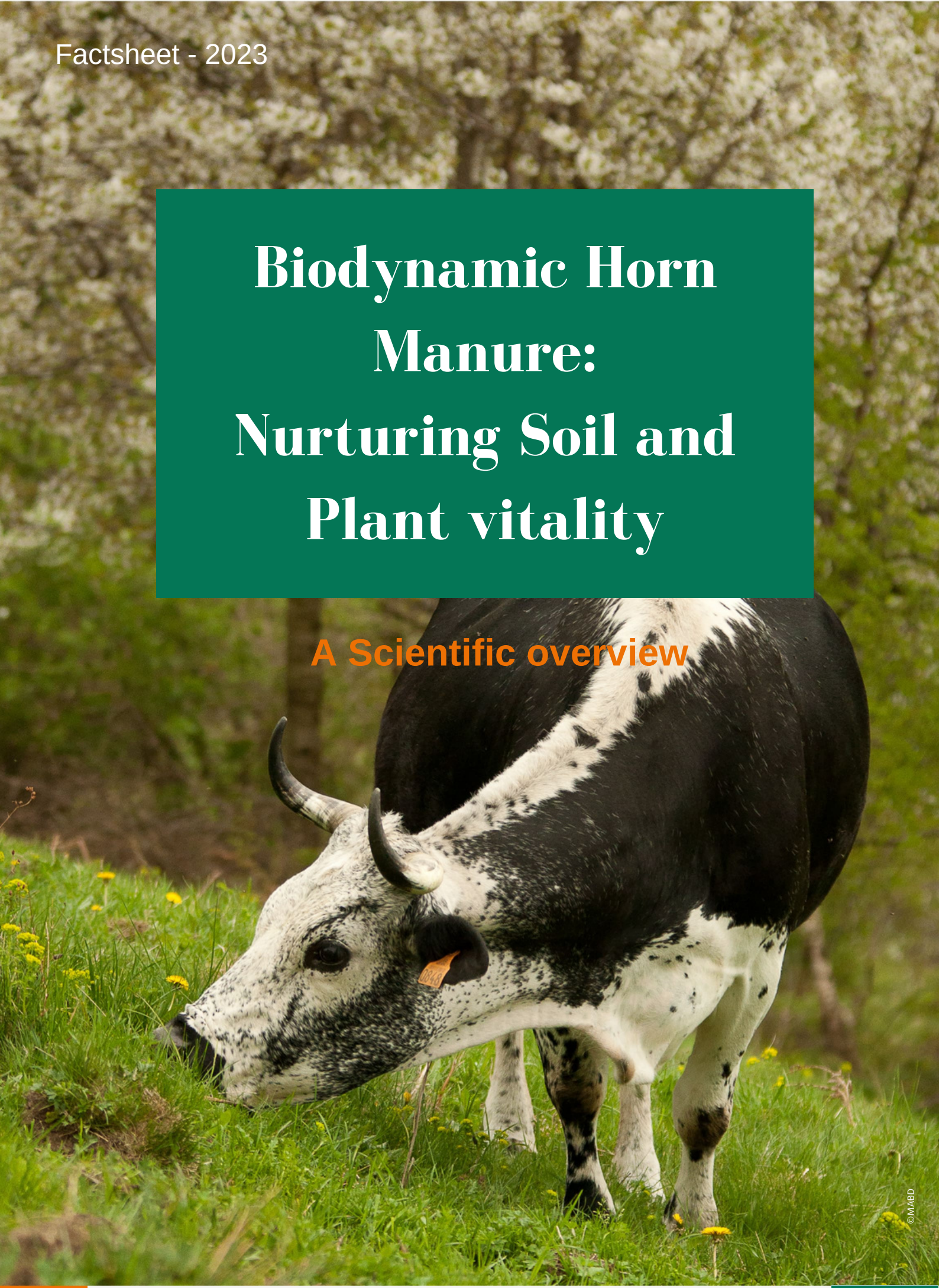
Factsheet - 2023

Biodynamic Horn Manure: Nurturing Soil and Plant vitality

A Scientific overview



demeter
Goetheanum Agriculture
Biodynamie Recherche
BIODYNAMIC FEDERATION demeter
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.

The digital version is hosted at the following adress: **sektion-landwirtschaft.org/en/research/basics**

Project funded by Software AG in 2023

The following booklet reviews the main results published in academic scientific journals. It focuses on the physical, chemical and microbiological properties of horn manure preparation (500) and its effects on soil and plant physiology.

SUMMARY

BIODYNAMIC HORN MANURE

Horn manure (500) is one of the main biodynamic preparations and is certainly among the most widely used, along with horn silica (501) and the preparations for treating compost. As such, it is the subject of much research aimed at characterising its effects and understanding its mode of action.

COMPOSITION

Biodynamic horn manure (500) is the final product of natural biotechnology based on the anaerobic humification process of manure. The relatively lower fungal activity during the anoxic humification of manure is conducive to a considerable content of aromatic compounds due to a partial degradation of manure' lignin. These phenolic lignin residues are known to have an intense biological activity that confers to the humified horn manure a significant biostimulation on plants, such as that exerted by the auxin hormone, even at very low doses.

ACTION

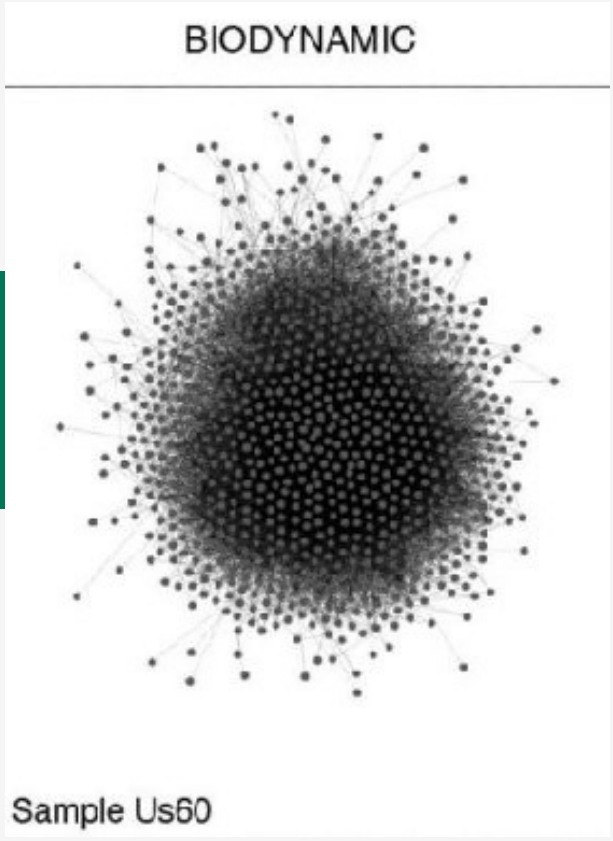
Horn manure stabilises and compensates plant growth and yield, fostering adaptation to different environmental conditions.

When horn manure is diluted and spread at 100g.ha^{-1}, as recommended by the Demeter standard, its final (nanomolar, 10^{-10}) concentration in the soil fits well within the known ranges of biological activity, which are effective on plants even at femtomolar (10^{-15}) concentrations.

EFFICACY

Laboratory bioassays have shown the effect of horn manure on cress root growth through a stabilising pattern of actions that regulate growth under stress conditions. This indicates the potential to increase the resilience of agricultural systems even in adverse soil environments, such as flooding and thermal shocks, as well as salinity and drought conditions.

Figure : **Specific organisation of fungal communities in soils according to cropping patterns**. Source : Ortiz-Álvarez et al, 2021.



SYSTEMIC STUDIES

Systemic studies found the soil microbiome, i.e., microbiological diversity, abundance and functionality, to be better under biodynamic management than in organic and conventional agriculture. This general improvement of the soil microbiological status can most likely be attributed to the use of horn manure even though there is no evident correlation.

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

MOLECULAR AND BIOLOGICAL PROPERTIES

Biodynamic horn manure is obtained through an anaerobic humification process of manure at a controlled temperature. The relatively low fungal activity during the anoxic humification of manure is conducive to a considerable content of aromatic compounds because lignin in manure degrades only partially. These phenolic lignin residues possess an intense biological activity so that humified horn manure has a large biostimulant effect on plants, comparable to that exerted by the auxin hormone, even at very low doses. Similar extremely small amounts of hormone-like plant biostimulants, such as algae, plant protein hydrolysates, and geochemical humic matter, sold by the agrochemical industry, are commonly applied in agricultural systems.

The molecular composition of horn manure has been described by a research group at the University of Naples Federico II (Spaccini et al., 2012). This study employed Nuclear Magnetic Resonance (NMR) spectroscopy and pyrolytic mass spectrometry. It revealed a complex molecular composition: phenolic derivatives of lignin (fibrous part of plants), plant polysaccharides (sugars), and linear and cyclic lipidic components (fats) of plant and microbial origin. This composition is similar to the various composts used in agriculture, but with a larger share of phenolic lignin residues.

What does this critical property mean? In ordinary mature compost, where humification processes are developed under aerobic conditions, the decomposition of unstable hydrophilic substances (such as carbohydrates), due mainly to bacteria, is accompanied by extensive degradation of lignin polymeric structures by fungi, while more hydrophobic compounds (such as fatty acids) are preferentially accumulated and incorporate bioactive phenolic residues. Conversely, the anaerobic humification of manure confined inside the cow horns reduces the fungal activity, thereby accumulating a more significant amount of phenolic residues that confer to horn manure a more significant biological activity towards plant growth.

IIn 2013, the same team (Giannattasio et al. 2013) studied the microbiological composition of horn manure. They verified its biostimulant activity on plants by evaluating the content of several enzymes having beneficial activity in the rhizosphere. This work determined that preparation 500 had a more significant level of different specific enzymes than that found in many soils, thus implying a considerably greater rhizosphere activity. In addition, the authors showed that horn manure contained an amount of auxin-like compounds (0.03 ppm) that is equivalent to a nanomolar auxin concentration in soil and more than enough to exert physiological modifications in plants, such as elongation of roots' primary and secondary branches. The large bacteria-to-fungi ratio found in the horn manure confirmed the previous study that reported on the significant content of phenolic compounds being the end-product of the anaerobic humification process and the intense biological activity of this biodynamic preparation.

ESTIMATE OF THE QUANTITY APPLIED IN A SOIL

The Demeter standard recommends that horn manure is diluted and spread at 100g.ha^{-1}.In this regard, the same authors (Giannattasio et al. 2013) presented a rational dilution approach to refuting the widespread rumour that biodynamic preparations are ineffective because of the small quantities applied. The biodynamic farming protocol prescribes dissolving about 100g of horn manure in 25 to 50L of water per hectare. In what volume of water does this amount of preparation arrive? The weight of one hectare of soil, considering a depth of 0 to 20 cm beneficial for the roots, is about 2,000 tons. The water contained in the soil represents, on average, ¼ of its weight or 500,000L. Therefore, applying 100g of horn manure on one hectare corresponds to diluting this 100g in 500,000 Lof water. This gives a concentration of 0.0002 g L^{-1}.

The authors then considered that horn manure is primarily composed of low molecular weight molecules, with an average molecular weight of 250 g.mol-1. Thus, they calculated a dilution to an auxin-like concentration of 1.6 µM in the soil solution. Such micromolar (10^{-6}) concentration should be considered very large regarding the biological activity. The current scientific knowledge shows evidence of the biological activity of compounds of microbial origin, even at extremely low dilution levels, as effectively triggering physiological changes in plants. There are examples of compounds inducing nodulation in legumes which exert their activity at concentrations as low as 0.1 nanomolar (10^{-10} M).

Furthermore, several other studies on bioactive molecules, even at femtomolar (10^{-15} M) concentrations, exist. This calculation indicates that the auxin-like bioactive compounds in horn manure may be present in soils with an average concentration of 20-30 nanomoles, large enough to ensure the required bioactivity towards plant growth. Hence, it is unsurprising that applying humified horn manure at the prescribed doses can bring soil molecular signals well within the known ranges of biological activity.

©Canva

LABORATORY TESTING

A bioassay in the laboratory has shown that horn manure had a significant effect on watercress' root growth, thus suggesting its potential to simulate plant growth and increase the resilience of agricultural systems.

An important methodology to study horn manure is to develop specific laboratory trials. At the Dottenfelderhof farm in Germany, a bioassay was designed to study this. This work aimed to produce robust and reliable data through a controlled and easily reproducible experimental setup. For this purpose, Alain Morau was inspired by a protocol developed by researchers in integrative medicine to test the influence of a highly diluted substance (in their case, mistletoe) on the development and morphology of watercress. The principle consisted in observing the first stages of development of watercress seeds grown in a hydroponic solution having received different concentrations of dynamised horn manure (0.1 µl and 1µl, plus a control modality without preparation).

The results of this study (Morau et al., 2020a) were the following:

- At the early growth stage, the cress root growth was susceptible to the effects of horn manure.
- The effect of horn manure was strongly dependent on time, but stable within many months.
- A stabilising pattern of action was significant, indicating the potential to increase the resilience of the agricultural system in practice.

COMPENSATORY EFFECT

It is assumed that horn manure stabilises and compensates plant growth and yield, fostering the adaptation of plants to different environmental conditions and protecting them from stresses.

A second set of experiments was conducted to better understand this stabilising or compensatory effect (Morau et al., 2020b). This involved investigating the interactions between the bioactivity of horn manure preparation and the following factors: water overdose (resulting in oxygen deficiency for the roots), gravistimulation stress, and exposure to fluorescent light. The idea is that when the plant is under reasonable stress (which does not compromise its development), the humified preparation 500 can help the plant recover. It is known that the application of humified organic matter to stressed plants renders the biostimulation effect much more visible and significant than when plants are growing in optimal conditions.

The conclusion from this second experimental trial was that the activity of humified horn manure showed a compensatory mode of action against the stressors of water overdose and gravistimulation. The humified horn manure appeared to interact with the plant sensory systems and stimulated the physiological adaptability of plants to the environment by increasing the self-regulation processes.

This compensatory effect of other humified biodynamic preparations (not only 500) was recently confirmed in a study by Jürgen Fritz and colleagues on five vineyard plots in Burgundy (Fritz et al., 2020). The hypothesis was that adding preparations would influence the functional microbial diversity specific to the vineyard. This was indeed observed. The results showed that, depending on the nature of the soil, applying the highly humified horn manure (500) and horn silica (501) preparation was adequate and supported the hypothesis that the biodynamic management based on humified preparations would have a regulating and balancing action on the soil environment. However, the effect of the biodynamic preparation would be variable according to the agronomic and soil conditions.

COMPENSATORY EFFECT

The soil microbiological activity was improved under biodynamic management compared to organic and conventional agriculture.

A team of Spanish and American researchers studied the microbial communities in 350 vineyard soils in the United States and Spain (Ortiz-Álvarez et al., 2021). Their results indicated that within a single ecosystem, the method of cultivation (conventional, organic or biodynamic) determines two strategies for assembling fungal communities in the soil: a generalist habitat in biodynamic farming soils or a specialised habitat in conventionally farmed soils.

The study shows that fungal proliferation promoted by biodynamic farming resembled a community structure similar to that of wild, cooperative environments, as opposed to the highly specialised environment found in conventionally farmed vineyards. These results suggest that the fungi population induced by humified biodynamic preparations leads to collaborative community networks that are likely more resilient to the constantly altered environment imposed by climate change and land use.

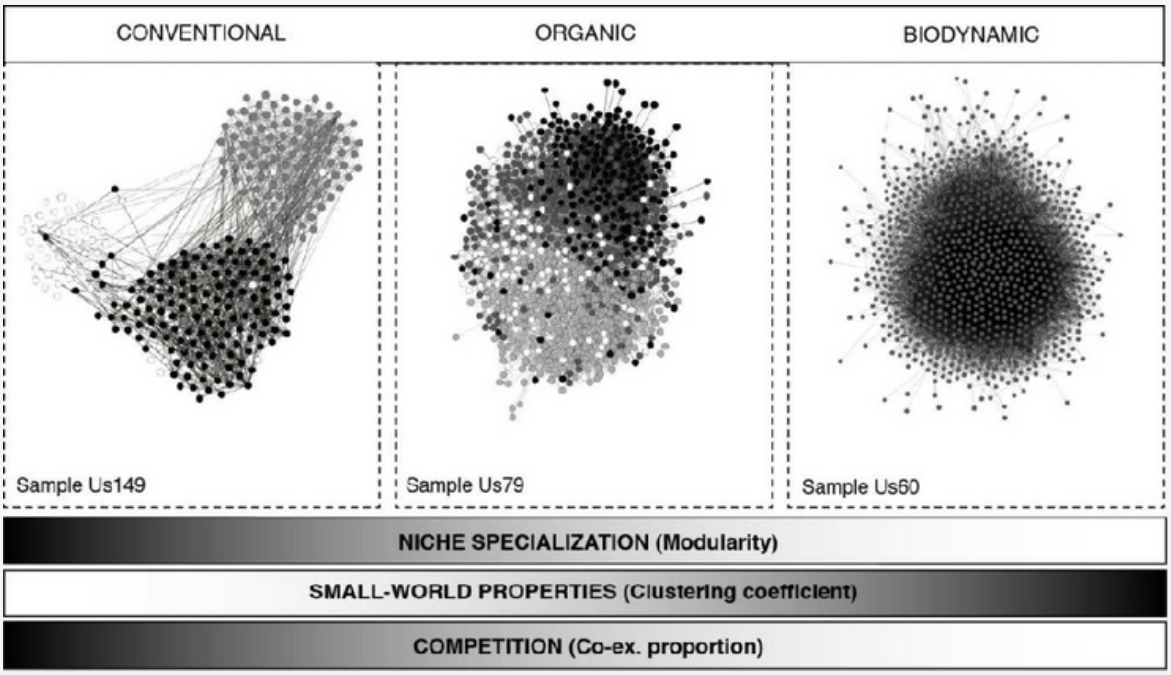


Figure : Specific organisation of fungal communities in soils according to cropping patterns. Source : Ortiz-Álvarez et al, 2021.

CONCLUSION

An analysis of the evidence present so far in the scientific literature on horn manure suggests that the humification process to which manure is subjected in prevalent anoxic conditions and controlled temperature provides the humified biodynamic preparation with a molecular and microbiological composition that confirms its capacity to exert significant effects as a plant biostimulant and soil bioeffector.

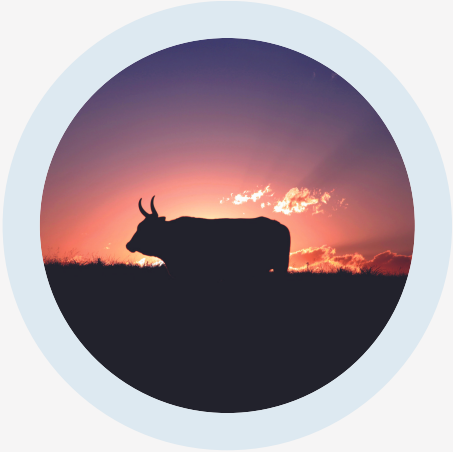
REFERENCES

Giannattasio M, Vendramin E, Fornasier F, Alberghini S, Zanardo M, Stellin F, Concheri G, Stevanato P, Ertani A, Nardi S, Rizzi V, Piffanelli P, Spaccini R, Mazzei P, Piccolo A, Squartini A. (2013) **Microbiological Features and Bioactivity of a Fermented Manure Product (Preparation 500) Used in Biodynamic Agriculture.** J. Microbiol. Biotechnol. 2013; 23:644-651. https://doi.org/10.4014/jmb.1212.12004

Jürgen Fritz, Ramia Jannoura, Finja Lauer, Jona Schenk, Pierre Masson & Rainer Georg Joergensen (2020) **Functional microbial diversity responses to biodynamic management in Burgundian vineyard soils,** Biological Agriculture & Horticulture, 36:3, 172-186, DOI: 10.1080/01448765.2020.1762739

Morau, A., Piepho, HP. & and Fritz, J. (2020a) **Growth responses of garden cress (Lepidium sativum L.) to biodynamic cow manure preparation in a bioassay**, Biological Agriculture & Horticulture, 36:1, 16-34, DOI: 10.1080/01448765.2019.1644668

Morau, A., Piepho, HP. (2020b) **Interactions between abiotic factors and the bioactivity of biodynamic horn manure on the growth of garden cress (Lepidium sativum L.) in a bioassay.** Chem. Biol. Technol. Agric. 7, 11 (2020). https://doi.org/10.1186/s40538-020-0176-x



Ortiz-Álvarez R, Ortega-Arranz H, Ontiveros VJ, de Celis M, Ravarani C, Acedo A, Belda I. (2021) **Network properties of local fungal communities reveal the anthropogenic disturbance consequences of farming practices in vineyard soils**. mSystems 6:e00344-21. https://doi.org/10.1128/mSystems.00344-21

Spaccini, R., Mazzei, P., Squartini, A. et al. (2012) **Molecular properties of a fermented manure preparation used as field spray in biodynamic agriculture**. Environ Sci Pollut Res 19, 4214–4225 (2012). https://doi.org/10.1007/s11356-012-1022-x

Photos :
1.©MABD 2.©YoolGmbH&Co 3.©MABD

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