BIODYNAMIC FARMING IN RESEARCH

A REVIEW OF INTERNATIONAL SCIENTIFIC LITERATURE

AUTHOR: DR. CHRISTOPHER BROCK
Research coordinator at Demeter e. V., Board of Directors Forschungsring e. v.
christopher.brock@demeter.de

Good news right from the start: the number of published studies on biodynamic farming in scientific journals is constantly increasing! This is partly due to the global growth of the biodynamic community and thus the visibility and importance in practice, but it could also reflect a growing curiosity and willingness among researchers to get involved in and get involved with biodynamic farming to deal with his impulses. Until the beginning of the 2000s, there were still individual works, but in a scientific overview article on the status of research in biodynamic farming, a total of 86 studies were evaluated up to 2017, which dealt with the topics of soil quality and soil health, and the effects of biodynamic preparations , food quality, viticulture, development of biodynamic farming and crop production issues in general (Brock et al. 2019). Since then, over 60 articles have been added, which are presented in the research ring's Biodynamic Research Newsletter, which appears up to four times a year in German and English (the newsletter can be subscribed to free of charge by email to newsletter@for-schungsring.de).

In most cases, the articles are dedicated to the system comparison of biodynamic and non-biodynamic management and their effects on soil, plants, food, animals and - unfortunately still very rarely - people. In terms of methods, the scientifically published studies use approaches that are currently scientifically recognized or fully understandable. This now also includes the so-called image-creating processes as holistic analysis methods, or effective sensor technology as a method that evaluates the emotional well-being of people.

The origin of the scientific contributions shows what also applies to biodynamic practice: Biodynamic researchers are increasingly a global movement that is gradually breaking away from historically based Eurocentrism. Although the majority of scientifically published studies currently come from Europe, the number of studies from other continents - especially Asia (specifically: India) and South America (especially Brazil) is increasing rapidly.

Since 2018, the Section for Agriculture at the Goe-theanum has been supporting the international networking of researchers in bio-dynamic agriculture and food industry with the Biodynamic Research Conference, which is taking place for the second time this year - unfortunately only online due to the uncertainties in the context of the corona pandemic (www.abteilung-landwirtschaft.org). Following the first conference, which took place from September 5th to 8th, 2018 at the Goethea-num in Dornach (CH), a special volume with twelve articles in English was published in the magazine Open Agriculture (plus an introduction by the editors). , which can be downloaded free of charge from the journal's website (www. degruyter.com/journal/key/OPAG/4/1/html – scroll down to the special issue).

So what is the state of knowledge in research on biodynamic mix agriculture in the scientific literature?

System effects

System comparisons between biodynamic, organic and conventional (or “integrated”) management are to date the most common approach in research on biodynamic farming. This makes particular sense for assessing the real situation in practice, since economic systems usually differ in complex ways and not just in individual factors. System comparisons therefore reflect reality particularly well, but on the other hand do not generally allow any conclusions to be drawn about the effect of individual factors, such as: B. the preparations.

In system comparisons under biodynamic management, soil fertility indicators are in the majority of studies more positive than under non-biodynamic management (see overview table). Larger reserves of soil organic matter, better soil structure and higher microbial activity and efficiency in the turnover of organic matter were observed. In a large-scale comparison of vineyard soils under conventional, organic-biological and biodynamic cultivation, a significantly higher functional diversity of the microorganism communities in the biodynamic soils was also found.

The more the systems differ from the non-biodynamic comparison systems, the greater the effects of biodynamic farming. This is particularly true for the

Development of soil organic matter reserves. With similar crop rotation and, above all, fertilization, no statistically valid differences were found in long-term experiments (e.g. Heitkamp et al. 2011 for the Darmstadt long-term experiment, Krauss et al. 2020 for the experiment in Frick). What is noteworthy, however, is that differences in the microorganism communities and associated characteristics were observed even with minor system differences - this could well indicate a direct effect of the preparations (more on this below).

System effects of biodynamic farming can also be seen in plants and animals, as shown in the overview table.
ren or animal products. Positive effects of biodynamic farming have often been observed, particularly when it comes to the ingredients of plant-based products. A particularly large number of studies come from viticulture - probably because quality issues have always played a central role here and are also treated in a much more differentiated manner than with most other foods. There are only a few studies on animal products. However, several studies have now shown that milk from biodynamic production is obviously better tolerated than milk from non-biodynamic systems.

Biodynamic preparations intensify the interaction between soil and plants

Biodynamic farming also generally performs well in broader sustainability analyzes - there are comparative studies from several countries. In the DOK trial, the biodynamic systems also had the lowest greenhouse gas emissions. However, there is a heated discussion about the recording of environmental impacts - the determination of the system boundaries, i.e. the factors that must be included in the analysis, plays a central role in the results.

In comparisons with non-biodynamic low-input systems, biodynamic farming also achieved significant increases in yield. However, this effect can also be achieved in other ways - e.g. For example, there are corresponding reports of the conversion to organic-biological systems - and is not a specific feature of biodynamic management. In comparison to conventional high-input systems or organic-biological systems with a higher level of plant-available nutrients due to fertilization, biodynamic farming usually has a significantly lower yield level.

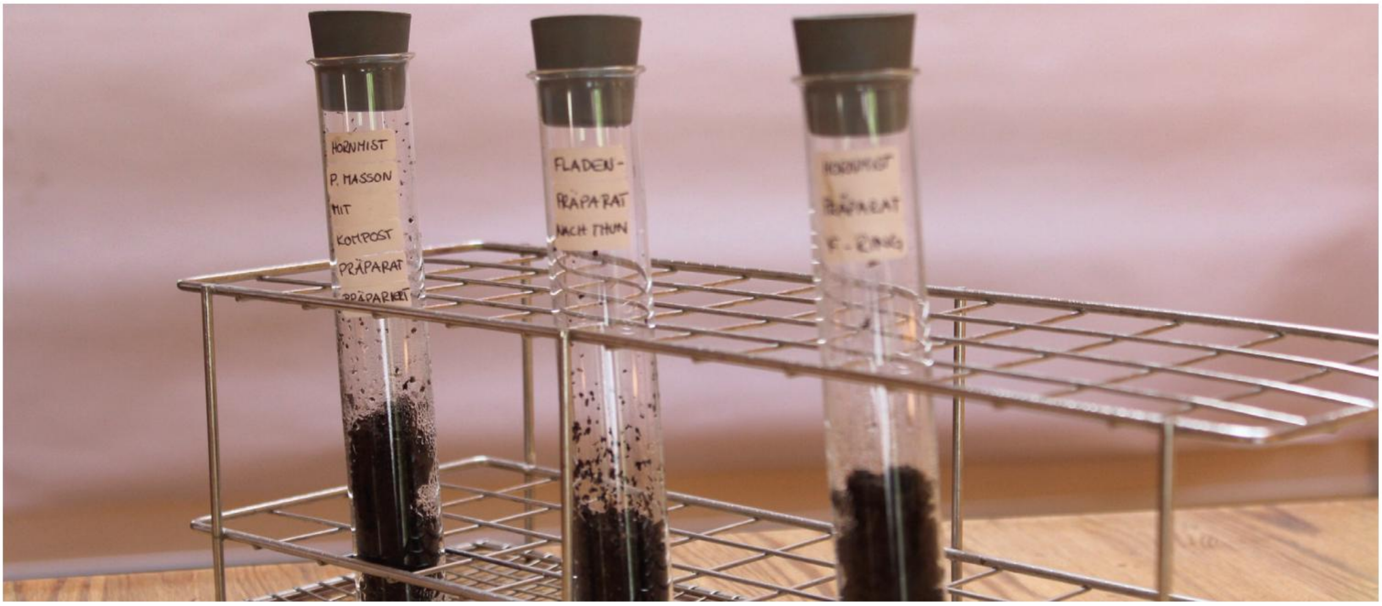
Effects of biodynamic preparations

The effects of the preparations have so far only been examined in a few studies independently of other factors. However, several studies have observed positive effects of preparations on soil parameters, as well as on yield and/or plant ingredients (see overview table). Above all, the effect of field spray preparations, horn manure and horn pebbles was examined, and more rarely the effect of compost preparations. However, indications of their effect may be provided by system comparisons in which differences in microbial characteristics were observed with otherwise very small system differences in terms of fertilization. In fact, when it comes to soil parameters, it is primarily biochemical and microbial characteristics that react to the application of the preparations. When it comes to ingredients, value-adding substances were increased in several studies, while value-decreasing ingredients (e.g. nitrate) had lower concentr

In the search for explanations for the observed effects of the preparations on the material level, several studies have been published in recent years that dealt with the characterization of the preparations. It was shown that the preparations create or promote microorganism communities, especially in the soil, whose properties can be linked to the observed effects of the preparations on plant growth.

Method development

The scientifically published works on biodynamic farming have so far primarily focused on classic chemical or biochemical, and more recently also biological, characteristics.



The different qualities of biodynamic preparations have not yet been researched

le as recorded by the microbiome. The methods are mostly reductionist, i.e. they only capture individual characteristics. In the search for more holistic methods that depict the condition of a sample or an object under investigation on a high and therefore complex level, the so-called image-creating methods were developed in biodynamic or anthroposophical research. In the meantime, several studies have already been published in which image-creating processes were used - from a scientific point of view, these methods (in particular copper chloride crystallization) must therefore be considered recognized. In a new scientifically published study, the importance of human sensitivity for the evaluation of images is even discussed (Doesburg et al. 2021).

Another scientifically recognized method as a building block for holistic investigation approaches is effect sensor technology, with which effects on people on the mental or emotional level are recorded (Geier et al. 2016). The procedure for effective sensor technology is methodically based on classic sensor technology. What both approaches have in common is that human perception serves as a tool for investigation - only in sensory technology it is about taste, whereas in effective sensory technology it is about the emotional state that is triggered. Effective sensor technology opens up access to the mental level and enormously expands the mainly (bio-)chemical portfolio of methods in food testing.

Inter- and transdisciplinary research approaches are not yet particularly developed (as is generally the case in the research landscape). For example, B. so far no methods from the Medicine or the social sciences are used in scientifically published studies, although in biodynamic farming we make people the basis for understanding agricultural operations.

Conclusion and outlook

Biodynamic farming has also arrived in the scientific community and is being researched with great seriousness - and hopefully a lot of joy. It is not about proving or disproving the anthroposophical foundations, but rather about a better understanding of the properties and potential of biodynamic farming. So far, effects have mainly been shown, now it's about explaining and understanding them. The methodological development work in this context is an exciting challenge for the researchers.

There are already some promising approaches that give everyone reason to look to the future with confidence and curiosity. •

literature

Brock C., Geier U., Greiner R., Olbrich-Majer M., Fritz J., 2019: Research in biodynamic food and farming - a review. Open Agriculture 4, 743–757. • Doesburg P., Fritz J., Athmann M., Bornhütter R., Busscher N., Geier U., Mergardt G., Scherr C., 2021: Kinesthetic engagement in Gestalt evaluation outscores analytical 'atomic feature' evaluation in perceiving aging in crystallization images of agricultural products. PlosOne 16, e0248124. • Geier U., Büssing A., Kruse P., Greiner R., Buchecker K., 2016: Development and application of a test for food-induced emotions. PlosOne 11, e0165991. • Heitkamp F., Raupp J., Ludwig B., 2011: Soil organic matter pools and crop yields as affected by the rate of farmyard manure and use of biodynamic preparations in a sandy soil. Organic Argriculture 1, 111–124.• Krauss M., Berner A., Perrochet F., Frei R., Niggli U., Mäder P., 2020: Enhanced soil quality with reduced tillage and solid manures in organic farming – a synthesis of 15 years. Scientific Reports 10, 4403.

CURRENT BIODYNAMIC RESEARCH: PROVEN EFFECTS IN THE SCIENTIFIC LITERATURE

fact-goal	Authors	publication	subject of Investigation	observation
	Jukneviciene et al. 2019	Open Agriculture 4, 452–459	Floor	Nutrient contents and enzyme activities increased
	Vaitkeviciene et al. 2019	Open Agriculture 4, 17–23	Floor	Nutrient contents and enzyme activities increased
	Valdez and Fernandez 2008	Philippean Journal of Crop Sciences 32, 37–58	Floor	P availability increased
	Reeve et al. 2010	Bioresource Technology 101, 5658–5666	compost	Dehydrogenase activity increased
	Zaller 2007	Analyzes of Applied Biology 151, 245–249	compost	Germination ability of dock seeds reduced by compost preparations
	Jariene et al. 2017	Biological Agriculture & Horticulture 33, 172–182	Plant	Polyphenol content and antioxidant capacity increased (potatoes)
	Jariene et al. 2018	Biological Agriculture & Horticulture 35, 132–142	Plant	Phenols and flavonoids increased by P500, decreased by P501 (mulberry, leaves)
	Jukneviciene et al. 2019	Open Agriculture 4, 452–459	Plant	antioxidant substances increased (pumpkin)
	Morau et al. 2020	Biological Agriculture & Horticulture 36, 16–34	Plant	Stabilization of the growth process (cress)
	Sharma et al. 2012	International Journal of Seed Spices 2, 7–11	Plant	Yield increase 30% (Kumin)
	Trivedi et al. 2013	AJAR 1, 60-64	Plant	Yield increase 27% (mung bean)
–	Tung and Fernandez 2007	Philippine Journal of Crop Sciences 32, 49–62	Plant	Yield increase 30% (soy)
	Vaitkeviciene et al. 2019	Open Agriculture 4, 17–23	Plant	Starch content increased (potatoes)
	Valdez and Fernandez 2008	Philippine Journal of Crop Sciences 32, 37–58	Plant	Yield increase 15-20% (rice); Root lengths and root mass increased
	Giannattasio et al. 2013	Journal of Microbiology and Biotechnology 23, 644–651	preparations	Microbial communities produce growth-promoting substances for plants
	Jayachandaran et al. 2016	International Journal of Current Microbiology and Applied Sciences 5, 186–192	preparations	Microbial communities produce growth-promoting substances for plants
	Radha and Rao 2014	Indian Journal of Microbiology 54, 413-418	preparations	Microbial communities produce growth-promoting substances for plants
	Ram et al. 2019a	Indian Journal of Agricultural Sciences 89, 210–214	Preparations	Composition promotes microbial activity
	Spaccini et al. 2012	Environmental Science and Pollution Research 19,4214-4225	preparations	Microbial communities produce growth-promoting substances for plants
	Supriva et al. 2019	Journal of Eco-friendly Agriculture 14, 72–74	preparations	Microbial communities produce growth-promoting substances for plants
	Vaish et al. 2021	Journal of Environmental Biology 42, 644–651	preparations	Microbial communities produce growth-promoting substances for plants
	Bliedtner et al. 2018	Geophysical Research Abstracts 20, EGU2018–15897	Floor	C supply increased
	Di Giacinto et al. 2020	OenoOne 54, 131–143	Floor	Microbiological properties positively influenced
	Faust et al. 2017	Applied Soil Ecology 114, 82–89	Floor	Microbial community changed (without assessment)
	Fliessbach et al. 2007	Agriculture, Ecosystems and the Environment 118, 273–284	Floor	Microbial C utilization efficiency increased
–	Gadermaier et al. 2012	Renewable Agriculture and Food Systems 27, 68–80	Floor	Microbial community changed (without assessment)
	Hartmann et al. 2015	ISME Journal 9, 1174–1197	Floor	Microbial community changed (without assessment)
	Heger et al. 2012	European Journal of Soil Biology 49, 31–36	Floor	Microbial community changed (without assessment)
	Hendgen et al. 2020	Plants 9(10), 1361	Floor	C supply increased; Storage density lower
	Jorgensen et al. 2010	Biology and Fertility of Soils 46, 303–307	Floor	Microbial community changed (without assessment)
	Marques et al. 2020	International Journal of Advanced Engineering Research and Science 7, 187–194	Floor	Soil quality closer to nature (wine growing)

As of 07/2021 (Only peer-reviewed studies in which an effect was observed, differentiated into system comparisons or specific preparation effects.)

fact-goal	Authors	publication	subject of Investigation	observation
	Ortiz-Alvarez et al. 2021	mSystems 6, e00344-21, DOI 10.1128/mSystems.00344-21.	Floor	functional microbial diversity higher (viticulture)
	Ram et al. 2019b	Indian Journal of Agricultural Sciences 61-65	Soil 89,	C and nutrient reserves increased
	Skinner et al. 2019	Scientific Reports 9, 1-10	Floor	GHG emissions lower
	Sradnick et al. 2018	Organic Agriculture 8, 29-38	Floor	microbial C use efficiency increased
	Abbring et al. 2019	Clinical & Experimental Allergy 49, 1013-1025	milk	Tolerability better
	Kusche et al. 2015	Journal of the Science of Food and Agriculture 95, 529–539	milk	Fatty acid pattern better
	Poulsen et al. 2020	Acta Agriculturae Scandinavica A – Animal Science 69, 131–135	milk	Fatty acid pattern better
	Pechrova and Vlasicova 2013	Agris On-line papers in Economics and Informatics V, 143–152	Sustainability	resource efficiency increased (Czech Republic)
	Pergola et al. 2016	Journal of Cleaner Production 142, 1-13	Sustainability	Lower environmental impact in apricot cultivation (Italy)
	Troiano et al. 2019	Ecological Indicators 97, 301–310	sustainability	better in multi-criteria assessment of ecology/economy/social issues (rocket production)
	Turinek et al. 2010	The Journal for Geography 5, 129–140	Sustainability	ecological footprint of agricultural production lower (Slovenia)
	Villanueva-Rey et al. 2014	Journal of Cleaner Production 65, 330-341	Sustainability	Lower environmental impact in viticulture (Spain)
	Bavec et al. 2010	Journal of Agriculture and Food Chemistry 58, 11825–11831	Plant	Polyphenol content increased (beetroot); antioxidant substances increased (beetroot); Sugar content increased (beetroot)
	Bavec et al. 2012	Acta Horticulturae 933, 577–583	Plant	Ascorbic acid increased (cabbage)
–	D'Evoli et al. 2010	Journal of Food Science 75, 94-99	Plants	antioxidant substances increased (strawberries); Ascorbic acid increased (strawberries)
	Döring et al. 2015	PlosOne 10, 1–28	Plant	Botrytis infection reduced (wine)
	Fritz et al. 2011	Biological Agriculture & Horticulture 27, 320–336	Plant	better overall physiological condition/ripeness (wheat)
	Fritz et al. 2020	OenoOne 54, DOI 10.20870/oeno-one.2020.54.2.2548	Plant	better overall physiological condition/maturity (wine)
	Heimler et al. 2009	Food Chemistry 114, 765–770	Plant	Antioxidant substances increased (Batavia lettuce)
	Heimler et al. 2011	Journal of the Science of Food and Agriculture 92, 551–556	Plant	Polyphenol content increased (Batavia lettuce); Antioxidant substances increased (chicory)
	Kjellenberg and Gransted 2015	Foods 3, 440–462	Plant	Dry matter increased (potatoes); Crude protein increased (potatoes); sensory better (potatoes) better overall physiological condition/ripeness (potatoes)
	Lucarini et al. 2012	Journal of the Science of Food and Agriculture 92, 2796–2799	Plant	Nitrate content reduced (lettuce, red radicchio)
	Maciel et al. 2011	British Food Journal 113, 1103-1113	Plant	antioxidant substances increased (mango)
	Maneva et al. (2017)	Agricultural Science and Technology 9, 42–44	Plant	Increase in yield (Kamut)
	Masi et al. 2017	European Food Research and Technology 243, 1519–1531	Plant	Polyphenol content increased (apples)
	Meissner et al. 2019	OenoOne 53, DOI 10.20870/ oeno-one.2019.53.4.2470	Plant	Acetic acid content reduced (wine); grape weight reduced (wine); Grapes less dense (wine)
	Nabie et al. 2017	Journal of Pharmacognosy and Phytochmistry 6, 212–219	Plant	Increase in yield (vegetables); Improved nutritional value (vegetables)
	Picchi et al. 2020	International Journal of Wine Research 12, 1–16	Plant	Phenol levels increased (wine) Better sensory properties (wine)
	Ram et al. 2019b	Indian Journal of Agricultural Sciences 89, 61–65	Plant	valuable ingredients increased (mango); Increase in yield (mango)

Drug effects in total or individually

Effects of the biodynamic system