Biodynamic farming research and transdisciplinary knowledge co-production: Exploring the synergies

Transdisciplinary research (TDR) values the inclusion of multiple worldviews for knowledge co-production. Biodynamic farming (BF) corresponds to a specific worldview, in which inner capacities play a major role. Through its century-old history, BF has proven to be an important source and catalyst for innovation. This ability can be fostered as part of TDR projects and inspire leading edge methodological innovations for the TDR field itself. The article provides multiple examples of such synergies, yet it is argued that much of the transformative potential remains to be activated.

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Transdisciplinarity (TD) is seen as a promising way of producing knowledge and decision-making, particularly relevant in the current context of the sustainability crisis (Lawrence et al. 2022). After several decades of development and improvement, TD might be on the verge of a shift from a marginal to a more mainstream status, as advocated in a recent report from OECD (2020) and in highly visible initiatives, such as the *Horizon Europe* program (Fischer et al. 2023). Transdisciplinarity research (TDR) is often characterized by the integration of multiple disciplinary perspectives (interdisciplinarity) and the inclusion of stakeholders at all stages of the knowledge production process (co-production; Lang et al. 2012). According to Scholz and Steiner (2015), TDR has a genuine transformative potential when it involves multiple "levels of reality", characterized by different laws and fundamental concepts, as proposed by renowned TD theorist Nicolescu (2014). Along this line, the inclusion of indigenous worldviews is a promising trend in TD initiatives (Robson-Williams et al. 2023). Particularly, indigenous worldviews offer different perspectives on human/nature relationships, whereas the relationship of domination (often associated with the Western worldview) is sometimes considered as the very root of the sustainability crisis (Folke et al. 2021). Indigenous worldviews are also often associated with valuable "Traditional Ecological Knowledge" (Lam et al. 2020), defined as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes 2018).

Western Europe has no remaining indigenous communities that are comparable to the Māori of New Zealand or the Aboriginal Australians. Yet, in the field of agriculture, biodynamic farming (BF) forms a well-identified community that relies on a specific worldview with remarkable relationships to nature and non-material realms (Rigolot and Quantin 2022). In 2019, it was estimated that about 5900 farms and 200,000 hectares were certified by the biodynamic label *Demeter* in 63 countries, not including the numerous uncertified farms that apply full or partial BF principles (Santoni et al. 2022). BF evolved progressively since its inception in 1924, as philosopher Rudolf Steiner outlined its philosophical and practical foundations in a series of eight "agricultural courses" in Koberwitz (Paull 2011). Whereas the value of indigenous knowledge is increasingly acknowledged in academia, the value of BF for TDR is contested (Parisi et al. 2021). With 100 years of history, one can debate whether BF can be considered similar to an indigenous worldview with valuable "Traditional Ecological Knowledge". BF emerged in the very middle of Western Europe, during the modernization/industrialization process. The importance still given today to its founder Rudolf Steiner also raises legitimate questions (Parisi et al. 2021).

The viewpoint adopted in this paper is that there are indeed major synergies between BF research and transdisciplinary knowledge co-production. After presenting the specific conception of life and knowledge production associated with BF, I will demonstrate why this conception is interesting to trigger: 1. sustainable innovations; 2. scientific discoveries and changes in agricultural practices; and 3. evolutions in the field of transdisciplinary knowledge co-production itself. Although I illustrate these points with ancient or pioneer examples, I conclude by stressing that much of the synergistic potential remains to be activated. >

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Biodynamic farming: A different conception of life and knowledge

According to its practitioners, BF corresponds first and foremost to a different conception of nature and life. This includes the premise that living beings are connected through not only material, but also non-material dimensions. This conception translates into specific relationships between human beings, other living beings, and knowledge (Rigolot and Quantin 2022). Several socio-anthropological studies have shown how these specific relationships manifest concretely in agricultural practices. For example, from more than 80 comprehensive interviews with biodynamic winegrowers and their close collaborators, Foyer et al. (2020) characterize the interactions between these farmers and their plants as inherently sensitive – driven by relations of care and companionship. Particularly, farmers consider that plants have their own agency, and develop different forms of communication with them (Foyer et al. 2020). The same attentiveness of biodynamic farmers to more-than-human agency is highlighted by Pigott (2021), with a special focus on soils. This author stresses the importance of careful reciprocities between soil biota and humans, involving the mysterious influences of above-ground bodies and entities (Pigott 2021).

Complementary to its specific conception of life, BF is also associated to a specific approach to knowledge and knowledge generation. To describe their relationship to knowledge, biodynamic farmers often refer to the "Goethean approach". This approach is part of the foundations settled by Steiner a century ago, in reference to scientist and poet Johann Wolfgang von Goethe (1749 to 1832). By contrast with an "extractive" approach to knowledge, the Goethean approach has been characterized by three aspects: 1. the rejection of an over-reliance on theory; 2. the grasping of nature as being in flux; and 3. the role of human faculties in understanding nature (Brook 2021 a). Further, the Goethean approach has been formalized as a process made of four well-defined stages in which careful observation plays a key role, each stage involving distinct human faculties, namely 1. perception; 2. imagination; 3. inspiration; and 4. intuition (Brook 2021 b). As developed in Steiner's early classical book The *Philosophy of Freedom* (1964; original work written in 1894), Goethean science breaks the Kantian division between subjective experience and objective reality, in such a way that achieving objectivity does not require one to bracket our subjective experience anymore, but rather to "discipline our consciousness" (McKanan 2018).

As a consequence of the Goethean approach, although the BF community recognizes the value of classical disciplinary science, the individual experiences of each farmer play a primary role in knowledge creation and development. Furthermore, as human faculties are central in this approach, it becomes conceivable that individuals with presumed exceptional faculties might have extraordinary insights, which is supposed to be the case of BF initiator Rudolf Steiner. In addition to fostering a specific conception of life and knowledge, Steiner also gave specific hints and recommendations during his agricultural courses. Particularly, three interrelated principles are often mentioned to specify the characteristics of BF compared to other forms of organic farming (Rigolot and Quantin 2022): 1. the perception of the farm as an *individual organism,* which is not only seen as a physical entity, but also includes socio-cultural, mental, and spiritual dimensions (Brock et al. 2019); 2. the use of "biodynamic preparations", which are mixtures of plants and manure or silica sand, and can be thought in a similar way as homeopathic remedies using ingredients from the farm (Krause et al. 2022); and 3. the integration of "cosmic rhythms" (movements of the moon, the sun, and the planets) in the planning of agricultural activities (Pigott 2021). To date, there is no identified mechanism in the natural sciences backing up the presumed effects of biodynamic preparations and cosmic rhythms on plant and animal physiology, which is why BF is considered by many scientists as pseudoscience (Parisi et al. 2021). Yet, consistent with the Goethean approach, every insight given in the agricultural courses was presented as an indication, not to be believed, but to be tested practically on the ground, and "experienced" by the farmers themselves. As proposed by Compagnone et al. (2018), rather than pseudoscience, it might be more relevant to talk about different forms of knowledge, such as peri-scientific knowledge, experiential knowledge, sensory or even super-sensory knowledge, that are integrated by BF farmers with scientific knowledge in a syncretic fashion (Foyer 2018).

Synergies with transdisciplinary knowledge co-production

Biodynamic farming as a source and catalyst of innovations

The different conception of life in BF results in specific (life-affirming) innovations, and its conception of knowledge (the Goethean approach) has been associated with a high level of creativity among farmers (Grandjean 2021). Consequently, BF has been a major source of innovation within and beyond the organic farming movement. From the beginning of organic farming, often associated with Lord Northbourne's *Look to the Land* (1940) manifesto (among others) in which the term organic was introduced, the theory and practice of organic agriculture in general has been profoundly inspired by BF (Paull 2011). In fact, BF involves and contributes to improving all key technical principles of organic farming, such as crop rotation, diversification, and the use of manures and composts (Rigolot and Quantin 2022). As a result of the importance given to the principle of seeing the farm as an individual organism, biodynamic farms might be particularly creative in the development of integrated crop-livestock systems. The relationship of care between BF farmers and their animals has stimulated innovations, such as techniques related to the implementation of "mother bound calf rearing" in dairy farms (Kusche et al. 2021), the management of animals kept "intact" (e. g., cows with horns), and the practice of on-farm slaughter (Probst and Spengler 2014). From a socio-economic perspective as well, many innovations are related to BF. For example, label-

ling with the BF label, *Demeter,* was created in 1932, predating organic certification by several decades (McKanan 2018). As part of the broader anthroposophical movement, BF is also closely related to the invention of the world's first ethical and ecological banks (e. g., *GLS Bank* in Germany, *Triodos* bank in the Netherlands), the practice of Community Supported Agriculture (CSA), and the Camphill movement dedicated to the education and integration of disabled people (McKanan 2018).

Importantly, as developed by Montes-Lihn (2017), innovation processes cannot be reduced to technical and socio-economic aspects, as they also involve values. This author shows how biodynamic farmers can play a major role as catalysts for ecological innovation in the wine producers' networks; as pioneers and trusted individuals (Montes-Lihn 2017). The biodynamic farmers' role as a catalyst for innovation is also noted by Hochedez (2016) in the context of the Swedish peri-urban countryside. The question whether this role of BF, as a source and catalyst for innovation, can be itself catalyzed is an important one for academic research. According to Aeberhard and Rist (2009), who studied the historical development of organic agriculture in Switzerland, the collaboration between biodynamic farmers, organic farmers, and academic scientists was particularly fruitful in the initial stage (from the 1920s to the 1970s). However, from the 1970s on Aeberhard and Rist (2009) observed an increasing marginalization and exclusion of BF from the mainstream science. Aeberhard and Rist (2009) call for an inversion of these process, by re-stimulating the knowledge exchange among actors with the application of TD concepts and research projects, which is at the core of the following sections.

Biodynamic farming as a trigger for scientific breakthroughs and changes in agricultural practices

To date, and to my knowledge, only a few projects have taken up Aeberhard and Rist's (2009) call to develop new TDR with biodynamic farmers. In this section, I will first introduce a recent example of a TDR project involving BF, known as the *REPERE* project, which has led to important scientific results and changes in agricultural practices, as developed by Masson et al. (2021). In the next paragraph I will discuss the potential for further scientific breakthroughs in future TDR projects. At the origin of the *REPERE* project, the increasing criticism toward the important use of pesticides in viticulture motivated a diverse network of conventional, organic, and biodynamic winegrowers, scientists, and other stakeholders to collaborate to find innovative solutions (Moneyron 2017). To overcome the strong tensions that surfaced at the beginning of the project, the researchers developed an original framework based on the identification of four types of relevant knowledge (i. e., knowledge from the education system, knowledge from the environment, personal and collective experiences), combined with a step-by-step process based on a consensus/dissensus dialectic (Moneyron 2017). Through this innovative process, the discussion between actors kept evolving through time, until a striking shared consensus statement was reached: the level of defenses to climatic and pathogen threats is higher in biodynamic grape leaves, compared to conventionally grown grape leaves (Soustre-Gacougnolle et al. 2018). As there were not enough organic winegrowers in the project, it was not possible to compare the level of defense between organic and biodynamic leaves. Yet this scientific result is striking, because it demonstrates an unexpected diversity in plant responses depending on management practices, suggesting unknown molecular regulations (Soustre-Gacougnolle et al. 2018). Moreover, new research questions emerged, such as the temporal evolution of regulations when farming practices change (Soustre-Gacougnolle et al. 2018). Furthermore, consistent with TDR principles, not only academic results but also concrete changes in practices were fostered by the *REPERE* project, resulting in a substantial decrease in herbicide use in the vineyards over the project (Masson et al. 2021). In a subsequent analysis, Madouas et al. (2023) demonstrated how these changes in practice were associated with a diversification of the winegrowers' vocabulary, associated with an evolution of individual and collective reasoning. After the consensus on the higher level of defense in biodynamic grape leaves was reached, Madouas et al. (2023) show how new conversations emerged among stakeholders, with a growing interest for all kinds of viticulture practices. Particularly, Madouas et al. (2023) report lively debates about the different principles of biodynamic practices, including cosmic rhythms and the underlying anthroposophical philosophy. Some conventional winegrowers started to implement tests of biodynamic preparations on portions of their plots. Yet they rejected other aspects of BF and refused to claim the *Demeter* label, in order to preserve their relations with other actors in the wine sector (Madouas et al. 2023). Farmers involved in the *REPERE* project also started to combine the use of biodynamic preparations with other practices developed in the project (e. g., mild tilling, inter-row made of local wild plant, etc.), which resulted in a unique from of viticulture practice found nowhere else, thereby transcending existing farming system classifications (Madouas et al. 2023).

The ability of BF to trigger scientific discoveries (such as the realisation about grape molecular regulations in the *REPERE* project) is a key point of controversy. Over the years, the effects of biodynamic preparations and cosmic rhythms keep intriguing some academic scientists. For example, Zürcher et al. (1998) found a spectacular correlation between the moon phases and the growth of trees. Although controlled experiments give mixed results (Chalker-Scott 2013), recent on-farm analysis suggests a much higher ecological quality in the soil of biodynamic farms, even compared to other organic farms (Christel et al. 2021). A long-term experiment set up in 1978 by the Research Institute of Organic Agriculture FiBL and Agroscope in Switzerland demonstrated a particularly interesting evolution of the soil quality and the soil organic carbon in the BF treatment, compared to both conventional and organic treatments (Krause et al. 2022). Although there is still no scientific understanding of the mechanisms behind BF practices, emerging sciences could bring some explanations in the near future, such as epigenetics, complex system and quantum science, all of which were somehow >

"anticipated" by BF (Wright 2021). These research areas have the potential to generate major scientific breakthroughs in the future, especially if they are increasingly associated with a TD approach. As I will develop in the next section, TD is a particularly relevant approach to study and develop further BF theory and practice (and vice versa).

Coevolution between biodynamic farming and transdisciplinary knowledge co-production

There are striking similarities between the Goethean approach to knowledge and TD epistemology. Both approaches endeavor to move beyond the classical distinction between subject and object, and both imply complexity and different "levels of reality" as defined by Nicolescu (2014; such as material and non-material realms in BF, as noted already by Aeberhard and Rist 2009). According to von Diest (2019), a major contribution of BF to the TDR field itself is related to the very Goethean notion of intuition, which is central in biodynamic farmers' decision-making process. Intuition can be defined as "a pervasive, involuntary, rapid way of knowing, offering access to tacit (internal, intangible) knowledge that complements analytic processes" (von Diest 2019). Whereas most agricultural research efforts to date have focused on explicit (formalized) knowledge, von Diest (2019) argues that aiming instead at recognizing and encouraging intuition, as proposed by BF, would be reinvigorating for agricultural research. Further, von Diest (2019) identifies strong synergies between this idea and the "emergent transdisciplinary design research" (ETDR) proposed by van Breda and Swilling (2019) in the South African context. The basic premise of ETDR is that most TD methodologies are not suited for contexts characterized by high levels of complexity, conflict, and social fluidity (van Breda and Swilling 2019). Especially in such fluid contexts, the ETDR states that TD researchers should develop their intuition. Von Diest (2019) argues that Steiner's insights and guidelines (such as the four stages of Goethean observation) and the BF farmers' experience could be very valuable. Particularly, developing intuition among TD researchers might be a pathway to integrate "more-than-human nature" as a genuine partner of TD projects, for example through Intuitive Interspecies Communication (ICC; Barrett et al. 2021). The idea of communicating with other species might sound quite speculative yet, but it could also be another area of scientific breakthrough triggered by BF, with direct applications for the TDR field itself (von Diest 2019).

In the European context, "experiential science" is another innovative form of TDR in which intuition plays a key role. This approach has been developed by academic scholar Baars (2011), who is also a former biodynamic farmer and cheese maker. With practical examples of research projects on organic farming, Baars (2011) illustrates how "experiential science" builds news theories by making implicit knowledge explicit and fosters intuition among farmers. In practice, for example, organizing a "masterclass" between pioneer farmers is presented as a promising way to stimulate exchanges of knowledge and experience, in a comparable way to a masterclass between professional musicians (Baars 2011). Finally, a last example of promising TD methodology to foster intuition is *Theory U* (Scharmer 2009). According to *Theory U,* transformative changes require shifts in both individual and collective perceptions and intentions within a system (Scharmer

FIGURE 1: Biodynamic farmers, advisors, and academic researchers co-producing knowledge on a biodynamic farm in Saint-Menoux, France.

2009). To facilitate such shifts, *Theory U* is associated with a process in three main stages, having noticeable similarities with the Goethean approach: 1. sensing; 2. presencing; and 3. realizing change (Drimie et al. 2018). Interestingly, the inventor of *Theory U,* Otto Scharmer, reported to have been deeply inspired in his thinking by the familial biodynamic farm (Scharmer 2009). *Theory U* has already proven to be useful in several TDR projects, for example to address power imbalances in food systems (Drimie et al. 2018). Altogether, these innovative TD methodologies (i. e., ETDR, experiential science, and *Theory U*) contribute to a wider, new generation of TDR projects acknowledging the importance of "inner transformations" (Woiwode et al. 2021). The collaboration with BF could be particularly useful for the development of this new stream of TDR.

Conclusion

In their analysis of the historical development of organic agriculture in Switzerland, Aeberhard and Rist (2009) consider the initial stage before the 1970s as a successful case of transdisciplinary knowledge co-production. They argue that the inclusion of biodynamic farmers was particularly beneficial because it enabled cross-fertilizations between different thought styles and collectives (Fleck 1980). In the present paper, multiple examples have been given to illustrate the role of BF as a source and catalyst of innovations. Yet, somehow paradoxically with the analysis of Aeberhard and Rist (2009), TD did not exist as a research field during the initial stage of organic farming development, as the term TD precisely begun to be used in academia as of the 1970s. The *REPERE* project is an example of how current TDR methodologies could further foster the role of BF to trigger scientific breakthroughs and changes in agricultural practices (Masson et al. 2021). As we have also seen in this paper, the potentiality for future scientific breakthroughs is plausible, although it is debatable. Finally, the Goethean approach to knowledge, underlying BF, has important similarities with TDR and especially with emerging TDR approaches integrating *intuition* and other *inner* dimensions (Woiwode et al. 2021).

Particularly, the emerging TDR approaches might have an important transformative potential, as they involve the deepest and more powerful "leverage points" for transformation, corresponding to worldviews and paradigms (Abson et al. 2017). As put by Roquebert and Debucquet (2022), BF provides a powerful *ecological imaginary* to overcome the relationship of domination toward nature, associated with the modern/Western worldview. However, because of this transformative potential the integration of BF in TDR projects might also be particularly controversial, as it deeply challenges the status-quo and existing power relationships (Siltaoja et al. 2020). More specifically, Siltaoja and their coauthors (2020) have identified different criticisms in society toward BF, such as the idea that biodynamic farmers would promote dangerous ideologies or fool the consumers (Siltaoja et al. 2020). The analysis of these criticisms, and whether they are justified or not is beyond the scope of this paper, which deliberately focuses on proved benefits of BF for knowledge co-production. Yet it is important to acknowledge that there are some risks in giving a more prominent role to BF in agricultural development, and in the use of its notions, such as intuition (van Breda and Swilling 2019). To mitigate these risks, it is essential to combine BF with multiple other sources. Along this line, Wright (2022) identifies strong synergies between biodynamic and indigenous worldviews, which could serve as a powerful catalyst for the sustainable transformation of farming systems.

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