Information sheet

Soil biodiversity management: A cross-system lever for climate change mitigation, ecosystem restoration and agricultural productivity

Marion Ferrat was commissioned by Belspo (Belgium), on behalf of BiodivERsA, to produce an issue brief based on the results of three BiodivClim projects — Microservices, GradCatch and BIOFAIR — funded under the 2019 joint call on Biodiversity and Climate Change.

Knowledge and methodology used

This Issue Brief is part of a series aiming to inform on practical, science-based strategies to make Europe's soils, forests, and landscapes more resilient based on the key results of the BiodivClim research projects funded by Biodiversa+.

The brief was drafted by Marion Ferrat in consultation with the BiodivClim Issue Briefs Working Group. The Working Group reviewed the brief in three stages: first, to agree on its overall direction; second, to assess the quality and accuracy of the draft; and finally, to review the last set of modifications. This final review was carried out only by the project leads, who are members of the Working Group, to ensure the brief accurately reflected their research.

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Foot notes:

1. Full project title: Predicting climate change impacts on the crop microbiome and cascading effects on ecosystem services delivery in agroecosystems.
2. Full project title: Using natural environmental gradients to decipher the adaptation of soil microbial communities to climate change.
3. Full project title: Biodiversity of soils and farming innovations for improved resilience in European wheat agrosystems.
4. Waibel, M.,and al. (2025). Tensions in tillage: Reduction in tillage intensity associates with lower wheat growth and nutritional grain quality despite enhanced soil biological indicators. *Agriculture, Ecosystems & Environment, 389*, 109675. https://doi.org/10.1016/j.agee.2025.109675.
5. Intergovernmental Panel on Climate Change. (2019). *Special report on climate change and land: Technical summary.*

   García-Palacios, I., and al. (2021). Multiple ecosystem responses at regional scale to climate change. *Nature Reviews Earth & Environment, 2*(8), 615–628. https://doi.org/10.1038/s43017-021-00178-4

6. Intergovernmental Panel on Climate Change. (2019). *Special report on climate change and land: Technical summary.*
7. Council of the European Union. (2025, April 10). *Soil monitoring law: Council reaches deal with Parliament* [Press release 270/25]. https://www.consilium.europa.eu/en/press/press-releases/2025/04/10/soil-monitoring-law-council-reaches-deal-with-parliament/
8. European Commission. (2021). *EU soil strategy for 2030: Reaping the benefits of healthy soils for people, food, nature and climate* (COM/2021/699 final). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0699
9. Intergovernmental Panel on Climate Change. (2019). *Special report on climate change and land: Technical summary.*
10. Han, X., and al. (2024). Soil organic matter properties drive microbial enzyme activities and greenhouse gas fluxes along an elevational gradient. *Geoderma, 449*, 116201. https://www.sciencedirect.com/science/article/pii/S0016706124002222

For further information, project publications:

MICROSERVICES (DOK trial, drought under organic versus conventional):

- Bintarti, A.F., Kost, E., Kundel, D., Conz, R.F., Mäder, P., Krause, H.-M., et al. (2025). Cropping system modulates the effect of spring drought on ammonia-oxidizing communities. Soil Biology and Biochemistry 201, 109658. doi: 10.1016/j.soilbio.2024.109658.
- Bublitz, T.A., Oliva, R.L., Hupe, A., and Joergensen, R.G. (2024). Optimization of the bicinchoninic acid assay for quantifying carbohydrates of soil extracellular polymeric substances. Plant and Soil 498(1), 699-709. doi: 10.1007/s11104-023-06447-z.
- Bublitz, T.A., Kost, E., Kundel, D., Alimi, O.I., Hupe, A., Mäder, P., et al. (2025). Soil extracellular polymeric substances and microbial biomass react differently to field induced drought stress in contrasting cropping systems at different wheat developmental stages. Biology and Fertility of Soils. doi: 10.1007/s00374-025-01918-0.
- Ceglar, A., Zampieri, M., Toreti, A., and Dentener, F. (2019). Observed northward migration of agro-climate zones in Europe will further accelerate under climate change. Earth's Future 7(9), 1088-1101. doi: 10.1029/2019ef001178.
- Krause, H.-M., Stehle, B., Mayer, J., Mayer, M., Steffens, M., Mäder, P., et al. (2022). Biological soil quality and soil organic carbon change in biodynamic, organic, and conventional farming systems after 42 years. Agronomy for Sustainable Development 42(6), 117. doi: 10.1007/s13593-022-00843-y.
- Kost, E., Kundel, D., Conz, R.F., Mäder, P., Krause, H.-M., Six, J., et al. (2024). Soil microbial resistance and resilience to drought under organic and conventional farming. European Journal of Soil Biology 123, 103690. doi: 10.1016/j.ejsobi.2024.103690.
- Hartmann, M., Frey, B., Mayer, J., Mader, P., and Widmer, F. (2015). Distinct soil microbial diversity under long-term organic and conventional farming. The ISME Journal 9(5), 1177-1194. doi: 10.1038/ismej.2014.210.

MICROSERVICES (future climate projections and links with soil biodiversity):

- Akritidis, D., Georgoulias, A.K., Lorilla, R.S., Kontoes, C., Ceglar, A., Toreti, A., et al. (2023). On the northward shift of agro-climatic zones in Europe under different climate change scenarios. Environmental Sciences Proceedings 26(1), 20.
- Bormpoudakis, D., Giannarakis, G., Sánchez-Cueto, P., Labouyrie, M., Orgiazzi, A., Panagos, P., et al. (Year). "Exploring the links between bacterial diversity with vegetation and soil parameters using soil metabarcoding data and Sentinel-2 indices", in: IGARSS 2024 - 2024 IEEE International Geoscience and Remote Sensing Symposium), 4261-4265.

GRADCATCH :

- Donhauser, J., Domenech-Pascual, A., Han, X., Jordaan, K., Ramond, J. B., Frossard, A., ... & Prieme, A. (2024). Modelling soil prokaryotic traits across environments with the trait sequence database ampliconTraits and the R package MicEnvMod. Ecological Informatics, 83, 102817.
- Han, X., Doménech-Pascual, A., Casas-Ruiz, J. P., Donhauser, J., Jordaan, K., Ramond, J. B., ... & Frossard, A. (2024). Soil organic matter properties drive

microbial enzyme activities and greenhouse gas fluxes along an elevational gradient. Geoderma, 449, 116993.

- Doménech-Pascual A. Rodriguez L.C., Han X., Casas-Ruiz J.P., Ferriol-Ciurana J., Donhauser J., Jordaan K., Allison S.D., Frossard A., Priemé A., Ramond J.B., and Romaní A.M. Aridity shapes soil microbial community composition but not their functions, accepted in Applied Ecology
- Han X., Doménech-Pascual A, Donhauser J., Mo L., Crowther T., Casas-Ruiz J.P., Jordaan K., Ramond J.-B., Romaní A.M., Priemé A., and Frossard A. Fungal diversity sustains soil multifunctionality across European biomes, under review
- Donhauser J., Han X., Doménech-Pascual A., Jordaan K., Casas-Ruiz J.P., Ramond J.-B., Romaní A.M., Frossard A. and Priemé A. Cross-continental soil prokaryotic phenotypic traits are driven by precipitation regime and land cover, under review

BIOFAIR:

- Bradáčová K., Weinmann M., Neumann G., Müller T. (2023). Biostimulanzien - eine Chance und Herausforderung für nachhaltige Pflanzenproduktion Hintergründe, Fallstudien und Forschungsergebnisse. BaWü Öko-Ackerbautag, Naturland, 16.11.2023, Emerkingen (Oral presentation).
- Cao, D., Heughebaert, L., Boffel, L., Stove, C., & Van Der Straeten, D. (2024). Simultaneous quantification of seven B vitamins from wheat grains using UHPLC-MS/MS. Food Chemistry. Vol. 453, pp. 139667. https://doi.org/10.1016/j.foodchem.2024.139667
- Cao, D., Michel, J., Lorer, E., Weinmann, M., Le Gouis, J., Leon, C., Perrochon, S., Alvarez, D., Leemans, V., Balanzategui, I., Moya Laraño, J., Sanchez Moreno, S., Symanczik, S., Waibel, M., Vanderschuren, H., Thonar, C., Delaplace, P. (2025). Climate change threatens nutritional quality of European winter wheat. Advanced Science, under review.
- Michel, J., Balanzategui-Guijarro, I., Cao, D., Hinsinger, P., Le Gouis, J., Moya-Laraño, J., Sánchez-Moreno, S., Symanczik, S., Vanderschuren, H., Van Der Straeten, D., Waibel, M., Weinmann, M., Thonar, C., Delaplace, P. (2025). Sustainable and resilient agroecosystems need complexity of soil food webs and multivariate soil health indicators. European Journal of Soil Science, under review.
- Michel, J., Leemans, V., Weinmann, M., Balanzategui-Guijarro, I., Bin, J., Biver, S., Blum, A., Börger, R., Cao, D., Him, S.L., Kirbas, G., Le Gouis, J., Moya-Laraño, J., Persyn, M., Pierreux, J., Quenon, A., Sanchez-Moreno, S., Vanden Brande, F., Van Der Straeten, D., Wagner, M., Waibel, M., Xayphrarath, A., Vanderschuren, H., Thonar, C., Delaplace, P. (2025). Trade-offs between agronomic yields and sustainability in winter wheat cropping systems under climate change mediated by soil organic matter content. PLOS Climate, accepted.
- Neuhoff, D., Neumann, G., & Weinmann, M. (2024). Testing plant growth promoting microorganisms (PGPMs) under real field conditions – Evidence from an interdisciplinary on-farm experiment in Germany. Frontiers in Plant Science, 14, Article 1324665. https://doi.org/10.3389/fpls.2023.1324665
- Waibel, M., Michel, J., Antoine, M., Balanzategui-Guijarro, I., Cao, D., Delaplace, P., Le Gouis, J., Alvarez, D., Léon, C., Manfroy, S., Moya-Laraño, J., Perrochon, S., Sanchez-Moreno, S., Santin-Montanya, I., Tenorio, J. L., Thonar, C., Vanderschuren, H., Van Der Straeten, D., Verlinde, T., Weinmann, M., Symanczik, S. (2025). Tensions in tillage: Reduction in tillage intensity associates with lower wheat

growth and nutritional grain quality despite enhanced soil biological indicators. Agriculture, Ecosystems and Environment. Vol. 389, pp. 109675. https://doi.org/10.1016/j.agee.2025.109675

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- Weinmann, M., et al., & Neumann, G. (2024). Wann lohnen sich Biostimulanzien wirklich? – Chancen und Grenzen ihrer Anwendung im Ackerbau. agrarheute. Retrieved from https://www.agrarheute.com/