

Rodica Pena, PhD

Forest ecophysiologicalist | Tree Physiology and Plant-Soil-Microbe Interactions under Climate Change

Personal Details

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Current Position	Senior Research Fellow
Institution	Department of Sustainable Land Management, School of Agriculture, Policy and Development, University of Reading,
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Academic Appointments and Qualifications

2022-2026	Senior researcher (NERC, Co-developer of the proposal), University of Reading, UK.
2024-2025	Visiting Professor, Transilvania University of Brasov, Romania.
2022	Habilitation (<i>venia legendi</i>) in Molecular Ecology and Tree Physiology, University of Göttingen, Germany.
2020-2022	Visiting research fellow (German Research Foundation), University of Reading, UK.
2017-2020	Academic Position for Habilitation, University of Göttingen, Germany.
2014-2017	Principal investigator (German Research Foundation - Project "Eigene Stelle"), University of Göttingen, Germany.
2011-2014	Postdoctoral fellow, University of Göttingen, Germany.
2011	PhD (<i>magna cum laude</i>), University of Göttingen, Germany.
2006-2011	Doctoral researcher (supervised by Prof. Andrea Polle), University of Göttingen, Germany.
2003-2006	Parental leave
2000-2003	Research Assistant, University of Bucharest, Romania (part-time position).
1998-2001	Teaching assistant, University of Ecology, Bucharest, Romania

1998-2000 MSc in Plant Embryology, University of Bucharest, Romania
 1994-1998 Diploma in Biology, University of Bucharest, Romania.

Academic Service and Professional Memberships

2011 - current Reviewer for scientific journals: Annals of Forest Science, Applied Microbiology and Biotechnology, Biogeosciences, Catena, Ecological Engineering, Ecosphere, Environmental and Experimental Botany, Fungal Ecology, Forest Ecology and Management, International Journal of Ecology and Eco solution, Journal of Applied Botany and Food Quality, Journal of Photochemistry and Photobiology, Mycorrhiza, Mycological Progress, New Phytologist, Open Life Sciences, Plant Biology, Pedosphere, PeerJ, Plant Physiology, Plos One, Soil Research, Soil Biology and Biochemistry, Tree structure and functions, Trees.

2015 - current Associate editor for Frontiers in Plant Science, Annals of Forest Science.

2022 - current Member of the Advisory Board of New Phytologist Journal.
 Member of the Organising Committee, 48th New Phytologist Symposium: Forest Interactions (2026, Switzerland).

2015 - current Society memberships: Ecological Society of Germany, Austria, and Switzerland (GfÖ), International Mycorrhiza Society (IMS), International Society of Root Research (ISRR), British Ecological Society (BES), British Society of Soil Science (BSSS), British Mycological Society (BMS).

Research Funding

<i>Project Title</i>	<i>Period</i>	<i>Amount (Euro)</i>	<i>Funding source</i>	<i>Role</i>
Contribution of ectomycorrhizal fungi to European beech drought-adaptive potential along a wide elevation range	2025-2026	8,000	Society for the Protection of Underground Networks	Single applicant

Digging into the "Gadgil effect": how the competitive balance between fungal guilds affects carbon and nitrogen cycling	2022 - 2026	495,422	NERC	Co-developer of the proposal
The shifts in mycorrhizal symbionts within individual tree species under anthropogenic soil nutrient alteration - the effects on forest ecosystem processes	2020 - 2022	100,200	German Science Foundation	Research Fellowship
Spatial metacommunity dynamics and positive species interactions - plant-fungus symbiosis in the coastal environment	2019 - 2022	140,000	German Science Foundation	Co-Investigator, three applicants
External mycelia of ectomycorrhizal fungi in forest ecosystems under the impact of management intensity and biodiversity." Biodiversity Exploratories.	2014 - 2017	124,244	German Science Foundation	Principal Investigator, single applicant
Relationships between mycorrhizal fungi and colonisation of <i>Salicornia</i> cytotypes: Implications for ecosystem functioning	2013 - 2016	100,000	Ministry for Science and Culture of Lower Saxony	Co-Investigator, two applicants

Not-funded projects

<i>Project Title</i>	<i>Year</i>	<i>Funding source</i>	<i>Role</i>
Improved sustainable crop production by plant root-fungal interactions fostered by intercropping trees in a climate change-resilient agroecosystem	2015	Ministry for Science and Culture of Lower Saxony	Single applicant
Mycorrhizal mycelia biomass and the dynamic of inter-guild fungal mycelial interactions in response to forest management and its effect on ecosystem functions	2016	German Science Foundation	Single applicant
Mechanistic integration of mycorrhizal fungi in the conceptual framework of anthropogenic-generated soil nutritional imbalance	2019	German Science Foundation	Single applicant

Functional diversity of mycorrhizal fungi along a tropical land-use gradient	2019	German Science Foundation	Two applicants
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Teaching and Supervision

2011-2020	<p>Teaching fellow</p> <ul style="list-style-type: none"> - Developed, taught, and examined sections of "Fundamentals of Forest Botany" (Undergraduate, 120-220 students per year). - Developed, taught, and examined lecture series and practicum "Mechanisms of stress tolerance: Mycorrhiza" within "Ecophysiology and Stress Physiology of Trees" (Postgraduate, 15-40 students per year). - Developed, taught, and examined the "Biodiversity" module within "Modern Methods in Ecology" (Postgraduate, 20-40 students). - Established and coordinated a doctoral student Journal Club, meeting twice monthly. - Led advanced laboratory courses for PhD doctoral students.
2017-2020	<p>Departmental Teaching coordinator</p> <ul style="list-style-type: none"> - Coordinated departmental teaching delivery and examinations. - Oversaw curriculum development and implementation.
2016 - current	<p>Research Advisor</p> <ul style="list-style-type: none"> - Served as member of PhD examination boards (2 candidates). - Co-supervised doctoral candidates (5 completed, all awarded <i>magna cum laude</i>; 2 ongoing). - Supervised Master's theses (5 completed, all awarded Outstanding). - Mentored undergraduate research assistants and honours thesis projects. - Served as examiner for Master's and Bachelor's theses.

Public Engagement and Outreach

2019	<p>Organiser <i>Night of Science</i>: "The secret life of the forests - the forest www (Wood Wide Web). Mycorrhiza." University of Göttingen. Germany</p>
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2019	Contributed to two popular science articles for children, “The Networked World of Plants” (Spektrum der Wissenschaft, ZEIT LEO).
2023-2024	My Soil Mates Project: 75th Anniversary Joint Grant of the British Society of Soil Science and Sociedad Española de Ciencia del Suelo. The project aimed to increase school students’ awareness and appreciation of soil biodiversity, encouraging them to protect and enhance it.
2024	Participating in the Community Festival at the University of Reading.
2025	Numerous direct contacts with local communities and forestry students in Romania through the SPUN Project, aimed at enhancing awareness and protection of soil fungal networks.

Publications

- 1) **Pena R**, Rogers A, Hales-Henao A, Soltangheisi A, Tibbett M (2026). Evaluation of competitive or synergistic effects on plant and rhizosphere responses to feremycorrhizal fungus *Austroboletus occidentalis* under contrasting substrate ecologies. *Rhizosphere* n/a. <https://doi.org/10.1016/j.rhisph.2026.101350>
- 2) **Pena R[#]**, Ammerschubert S, Müller M, Schneider D, Daniel R, Gailing O, Polle A[#] (2026). Nitrogen mediates root–fungal effects on European beech biomass but not adaptability to the environment. *Journal of Applied Ecology* n/a, e70241. <https://doi.org/10.1111/1365-2664.70241>
- 3) Kariman K, Rengel Z, **Pena R**, Rahimlou S, Tibbett M (2025). A comparative analysis of fungi involved in plant nutrition. *Plant and Soil* <https://doi.org/10.1007/s11104-025-08120-z>.
- 4) Ryadin A, Edy N, Yelianti U, **Pena R[#]**, Polle, A[#] (2025). Fungal succession, litter decomposition and root nitrogen supply in a tropical oil palm plantation. *Plant and Soil*. <https://doi.org/10.1007/s11104-025-07962-x>
- 5) **Pena R[#]**, Milner G, Tibbett M (2025). Saprotrophic-ectomycorrhizal fungal interactions affect poplar performance. *Environmental and Experimental Botany* 238, 106246. <https://doi.org/10.1016/j.envexpbot.2025.106246>
- 6) **Pena R[#]**, Awad A, Nawaz A, Shang Y, Wubet T, Tibbett M (2025). Unravelling the facilitation-competition continuum among ectomycorrhizal and saprotrophic fungi. *Soil Biology and Biochemistry* 208, 109865. <https://doi.org/10.1016/j.soilbio.2025.109865>
- 7) **Pena R[#]**, Tibbett M (2024). Mycorrhizal symbiosis and the nitrogen nutrition of forest trees. *Applied Microbiology and Biotechnology* 108, 461. doi:10.1007/s00253-024-13298-w
- 8) Song B, Fang J, Yu Z, Liu Z, Li N, **Pena R**, Hu Z, Xu Z, Adams JM, Razavi BS (2024). The development of biological soil crust along the time series is mediated by archaeal communities. *Geoderma* 449, 117022. <https://doi.org/10.1016/j.geoderma.2024.117022>
- 9) Kariman K, Rengel Z, **Pena R**, Rahimlou S, Tibbett M (2024). The necessity to expand mycorrhizal boundaries: including the fungal endophytes that possess key mycorrhizal criteria. *Pedosphere*. 2024.01.004. <https://doi.org/10.1016/j.pedsph.2024.01.004>
- 10) **Pena R** (2024). Root-associated fungal communities: critical linkages between plants and soil. Understanding Their Structure and Function to Predict the Impacts of Environmental Change. *Cuvillier Verlag*. ISBN- 9783736979642

- 11) **Pena R**, Bluhm SL, Ammerschubert S, Agüi-Gonzalez P, Rizzoli SO, Scheu S, Polle A (2023). Mycorrhizal C/N ratio determines plant-derived carbon and nitrogen allocation to symbiosis *Communications Biology*. <https://doi.org/10.1038/s42003-023-05591-7>
- 12) Awad A, **Pena R**[#] (2023). An Improved Method for Extraction of Soil Fungal Mycelium. Awad, Abdallah and Pena, Rodica, An Improved Method for Extraction of Soil Fungal Mycelium. *MethodsX*, 11. 102477 <https://doi.org/10.1016/j.mex.2023.102477>
- 13) Song B, Razavi BS, **Pena R**[#] (2022). Contrasting distribution of enzyme activities in the rhizosphere of European beech and Norway spruce. *Frontiers in Plant Science* 13, 987112. <https://doi.org/10.3389/fpls.2022.987112>
- 14) Gonçalves DR, **Pena R**, Albach D (2022). Polyploidy and plant-fungus symbiosis: evidence of cytotypic-specific microbiomes in the halophyte *Salicornia* (Amaranthaceae). *BioRxiv*. <https://doi.org/10.1101/2022.03.09.483717>
- 15) Kariman K, Rengel Z, **Pena R**, Rahimlou S, Tibbett M (2022). Response to "Feremycorrhizal fungi: A confusing and erroneous term": Feremycorrhiza means 'nearly mycorrhiza'; hence, it is a clear and correct term because the fungal partner has mycorrhizal traits and lineage. *Soil Biology and Biochemistry* 177, 108934. <https://doi.org/10.1016/j.soilbio.2022.108934>
- 16) Degani E, Prasad MVR, Paradkar A, **Pena R**, Soltangheisi A, Ullah I, Warr B, Tibbett M. (2022). A critical review of *Pongamia pinnata* multiple applications: From land remediation and carbon sequestration to socioeconomic benefits. *Journal of Environmental Management* 324, 116297. <https://doi.org/10.1016/j.jenvman.2022.116297>
- 17) Clausing S, **Pena R**, Song B, Müller K, Mayer-Gruner P, Marhan S, Grafe M, Schulz S, Krüger J, Lang F, Schloter M, Kandeler E, Polle A (2021). Carbohydrate depletion in roots impedes phosphorus nutrition in young forest trees. *New Phytologist* 229:2611–2624. <https://doi.org/10.1111/nph.17058>
- 18) Gonçalves D, **Pena R**, Zotz G, Albach D (2021). Effects of fungal inoculation on the growth of *Salicornia* (Amaranthaceae) under different salinity conditions. *Symbiosis* 84. <https://doi.org/10.1007/s13199-021-00783-3>
- 19) Köhler J, Yang N, **Pena R**, Polle A, Meier IC (2021). Drought deteriorates the N stoichiometry of biomass production in European beech saplings under global change. *Frontiers in Global Change* 4. <https://doi.org/10.3389/ffgc.2021.647360>
- 20) Simons NK, Felipe-Lucia MR, Schall P, Ammer C, Bauhus J, Blüthgen N, Boch S, Buscot F, Fischer M, Goldmann K, Gossner MM, Hänsel F, Jung K, Manning P, Nauss T, Oelmann Y, **Pena R**, Polle A, Renner SC, Schloter M, Schöning I, Schulze E-D, Solly EF, Sorkau E, Stempfhuber B, Wubet T, Müller J, Seibold S, Weisser WW (2021). National Forest Inventories capture the multifunctionality of managed forests in Germany. *Forest Ecosystems* 8, 5. <https://doi.org/10.1186/s40663-021-00280-5>
- 21) Yang N, Wang B, Liu D, Wang X, Li X, Zhang Y, Xu Y, Peng S, Ge Z, Mao L, Ruan H, **Pena R**[#] (2021). Long-term nitrogen deposition alters ectomycorrhizal community composition and function in a poplar plantation. *Journal of Fungi* 7: 791. <https://doi.org/10.3390/jof7100791>
- 22) Nguyen DQ, Schneider D, Brinkmann N, Song B, Janz D, Schöning I, Daniel R, **Pena R**[#], Polle A[#] (2020). Soil and root nutrient chemistry structure root-associated fungal assemblages in temperate forests. *Environmental Microbiology* 22:3081–3095. <https://doi.org/10.1111/1462-2920.15037>
- 23) Edy N, Yelianti U, Irawan B, Polle A, **Pena R**[#] (2020). Differences in root nitrogen uptake between tropical lowland rainforests and oil palm plantations. *Frontiers in Plant Science* 11. <https://doi.org/10.3389/fpls.2020.00092>
- 24) Goldmann K, Ammerschubert S, **Pena R**, Polle A, Wu B-W, Wubet T, Buscot F (2020). Early stage root-associated fungi show a high temporal turnover, but are independent of beech progeny. *Microorganisms* 8. <https://doi.org/10.3390/microorganisms8020210>
- 25) Yang N, Butenschoen O, Rana R, Koehler L, Hertel D, Leuschner C, Scheu S, Polle A, **Pena R**[#] (2019). Leaf litter species identity influences biochemical composition of ectomycorrhizal fungi. *Mycorrhiza* 29(2):85-96. <https://doi.org/10.1007/s00572-018-0876-2>
- 26) Awad A, Majcherczyk A, Schall P, Schroeter K, Schoening I, Schrupf M, Ehbrecht M, Boch S, Kahl T, Bauhus J, Seidel D, Ammer C, Fischer M, Kües U, **Pena R**[#] (2019). Ectomycorrhizal

and saprotrophic soil fungal biomass are driven by different factors and vary among broadleaf and coniferous temperate forests. *Soil Biology and Biochemistry* 131:9-18. <https://doi.org/10.1016/j.soilbio.2018.12.014>

- 27) Penone C, Allan E, Soliveres S, Felipe-Lucia M, Gossner MM, Seibold S, Simons NK, Schall P, van der Plas F, Manning P, Manzanedo RD, Boch S, Prati D, Ammer C, Bauhus J, Buscot F, Ehbrecht M, Goldmann K, Jung K, Müller J, Müller JC, **Pena R**, Polle A, Renner SC, Ruess L, Schoening I, Schrupf M, Solly EF, Tschapka M, Weisser WW, Wubet T, Fischer, M (2019). Specialisation and diversity of multiple trophic groups are promoted by different forest features. *Ecology Letters* 22:170-180. <https://doi.org/10.1111/ele.13182>
- 28) Bluhm SL, Eitzinger B, Ferlian O, Bluhm C, Schröter K, **Pena R**, Maraun M, Scheu S (2019). Deprivation of root-derived resources affects microbial biomass but not community structure in litter and soil. *PLOS ONE* 14: e0214233. <https://doi.org/10.1371/journal.pone.0214233>
- 29) Schroeter K*, Wemheuer B*, **Pena R***, Schoening I, Ehbrecht M, Schall P, Ammer C, Daniel R, Polle A (2019). Assembly processes of trophic guilds in the root mycobiome of temperate forests. *Molecular Ecology* 28(2):348-364. <https://doi.org/10.1111/mec.14887>
- 30) Magh R-K, Yang F, Rehschuh S, Burger M, Dannenmann M, **Pena R**, Burzlaff T, Ivanković M, Rennenberg H (2018). Nitrogen nutrition of European beech is maintained at sufficient water supply in mixed beech-fir stands. *Forests* 9:733. <https://doi.org/10.3390/f9120733>
- 31) Felipe-Lucia M, Soliveres S, Penone C, Manning P, van der Plas F, Boch S, Prati D, Ammer C, Schall P, Gossner M, Bauhus J, Buscot F, Blaser S, Blüthgen N, de Fritos A, Ehbrecht M, Frank K, Goldmann K, Hänsel F, Jung K, Kahl T, Nauss T, Oelmann Y, **Pena R**, Polle A, Renner S, Schloter M, Schoening I, Schrupf M, Schulze E-D, Solly E, Sorkau E, Stempfhuber B, Tschapka M, Weisser W, Wubet T, Fischer M, Allan E (2018). Multiple forest attributes underpin the provision of multiple ecosystem services. *Nature Communications* 9, Article number:4839. <https://doi.org/10.1038/s41467-018-07082-4>
- 32) Koehler J, Yang N, **Pena R**, Raghavan V, Polle A, Meier IC (2018). Ectomycorrhizal fungal diversity increases P uptake efficiency of European beech. *New Phytologist* 220 (4):12001210. <https://doi.org/10.1111/nph.15208>
- 33) Rana R, Herz K, Bruelheide H, Dietze S, Haider S, Jandt U, **Pena R**# (2018). Leaf Attenuated Total Reflection Fourier Transform Infrared (ATR-FTIR) biochemical profile of grassland plant species related to land-use intensity. *Ecological Indicators* 84:803-810. <https://doi.org/10.1016/j.ecolind.2017.09.047>
- 34) Lang F, Krüger J, Amelung W, Willbold S, Frossard E, Bünemann E, Bauhus J, Nitschke R, Kandeler E, Marhan S, Schulz S, Bergkemper F, Schloter M, Luster J, Guggisberg F, Kaiser K, Mikutta R, Guggenberger G, Polle A, **Pena R**, Prietzel J, Rodionov A, Talkner U, Meesenburg H, von Wilpert K, Hoelscher A, Dietrich HP, Chmara I (2017). Soil phosphorus supply controls P nutrition strategies of beech forest ecosystems in Central Europe. *Biogeochemistry* 136: 5-29. <https://doi.org/10.1007/s10533-017-0375-0>
- 35) Nguyen QD, **Pena R**, Polle A (2017). Impact of ectomycorrhizal community composition and soil treatment on inorganic nitrogen nutrition and performance of beech (*Fagus sylvatica* L.) provenances. *Trees* 31: 1891-1904. <https://doi.org/10.1007/s00468-017-1594-7>
- 36) Simon J, Dannenmann M, **Pena R**, Gessler A, Rennenberg H (2017). Nitrogen nutrition of beech forests in a changing climate: Importance of plant-soil-microbe water, carbon, and nitrogen interactions. *Marschner Review. Plant and Soil* 418:89-114. <https://doi.org/10.1007/s11104-017-3293-y>
- 37) Nguyen QN, Polle A, **Pena R**# (2017). Intraspecific variations in drought response and fitness traits of beech (*Fagus sylvatica* L.) seedlings from three provenances differing in annual precipitation. *Trees* 3:1215-1225. <https://doi.org/10.1007/s00468-017-1539-1>
- 38) **Pena R**, Lang C, Lohaus G, Boch S, Schall P, Ammer C, Fischer M, Polle A (2017). Phylogenetic and functional traits of ectomycorrhizal assemblages in top soil from different biogeographic regions and forest types. *Mycorrhiza* 27: 233. <https://doi.org/10.1007/s00572-016-0742-z>
- 39) Verbruggen E, **Pena R**, Fernandez C.W, Soong JL (2017). Mycorrhizal interactions with saprotrophs and impact on soil carbon storage, in N.C Johnson, C. Gehring and J. Jansa (Ed.) *Mycorrhizal Mediation of Soil. Elsevier*. <https://doi.org/10.1016/B978-0-12-804312-7.00024-3>

- 40) Goldmann K, Schroeter K, **Pena R**, Schoening I, Schrupf M, Buscot F, Polle A, Wubet T (2016). Divergent habitat filtering of root and soil fungal communities in temperate beech forests. *Scientific Reports* 6: 31439. <https://doi.org/10.1038/srep31439>
- 41) **Pena R** (2016). Nitrogen acquisition in ectomycorrhizal symbiosis, in F. Martin (Ed.) *Molecular Mycorrhizal Symbiosis*. John Wiley & Sons. <https://doi.org/10.1002/9781118951446.ch11>
- 42) Zavišić A, Nassal P, Yang N, Heuck C, Spohn M, Marhan S, **Pena R**, Kandeler E, Polle A (2016). Phosphorus availabilities in beech (*Fagus sylvatica* L.) forests impose habitat filtering on ectomycorrhizal communities and impact tree nutrition. *Soil Biology and Biochemistry* 98:127-137. <https://doi.org/10.1016/j.soilbio.2016.04.006>
- 43) Yang N, Zavišić A, **Pena R**, Polle A (2016.) Phenology, photosynthesis, and phosphorus in European beech (*Fagus sylvatica* L.) in two forest soils with contrasting P contents. *Journal of Plant Nutrition and Soil Science* 179: 151-158. <https://doi.org/10.1002/jpln.201500539>
- 44) Yang N, Schützenmeister K, Grubert D, Jungkunst F, Gansert D, Scheu S, Polle A, **Pena R**# (2015). Impacts of earthworms on nitrogen acquisition from leaf litter by arbuscular mycorrhizal ash and ectomycorrhizal beech trees. *Environmental and Experimental Botany* 120:1-7. <https://doi.org/10.1016/j.envexpbot.2015.06.013>
- 45) **Pena R**#, Lang C, Naumann A, Polle A. (2014). Ectomycorrhizal fungal identification in environmental samples of tree roots by Fourier-transform infrared (FTIR) spectroscopy. *Frontiers in Plant Science* 5:229. <https://doi.org/10.3389/fpls.2014.00229>
- 46) **Pena R**, Polle A (2014). Attributing functions to ectomycorrhizal fungal identities in assemblages for nitrogen acquisition under stress. *ISME Journal* 8:321-330. <https://doi.org/10.1038/ismej.2013.158>
- 47) **Pena R**, Tejedor J, Zeller B, Dannenman M, Polle A (2013). Interspecific temporal and spatial differences in the acquisition of litter-derived nitrogen by ectomycorrhizal fungal assemblages. *New Phytologist* 199:520–528.
- 48) **Pena R**, Simon J, Rennenberg H, Polle A (2013). Ectomycorrhiza affect architecture and nitrogen partitioning of beech (*Fagus sylvatica* L.) seedlings under shade and drought. *Environmental and Experimental Botany* 87:207-217. <https://doi.org/10.1016/j.envexpbot.2012.11.005>
- 49) Guo C, Simon J, Gasche R, Naumann PS, Bimüller C, **Pena R**, Polle A, Koegel-Knabner I, Zeller B, Rennenberg H, Dannenmann M (2013). Minor contribution of leaf litter to N nutrition of beech (*Fagus sylvatica*) seedlings in a mountainous beech forest of Southern Germany. *Plant and Soil* 369: 657-668. <https://doi.org/10.1007/s11104-012-1521-z>
- 50) **Pena R** (2011). Functional diversity of beech (*Fagus sylvatica* L.) ectomycorrhizas with respect to nitrogen nutrition in response to plant carbon supply. *Cuvillier Verlag*. ISBN-9783869558912
- 51) **Pena R**, Offermann C, Simon J, Naumann P S, Geßler A, Holst J, Dannenmann M, Mayer H, Koegel-Knabner I, Rennenberg H, and Polle A (2010). Girdling affects ectomycorrhizal fungal (EMF) diversity and reveals functional differences in EMF community composition in a beech forest. *Applied and Environmental Microbiology* 76:1831-1841. <https://doi.org/10.1128/AEM.01703-09>
- 52) Dannenmann M, Simon J, Gasche R, Holst J, Naumann P S, Koegel-Knabner I, Knicker H, Mayer H, Schloter M, **Pena R**, Polle A, Rennenberg H, and Papen H (2009). Tree girdling provides insight into the role of labile carbon in the competitive balance of N partitioning between soil microorganisms and adult European beech. *Soil Biology and Biochemistry* 41:1622–1631. <https://doi.org/10.1016/j.soilbio.2009.04.024>
- 53) Winkler J B, Dannenmann M, Simon J, **Pena R**, Offermann C, Sternad W, Clemenz C, Naumann P S, Gasche R, Koegel-Knabner I, Gessler A, Rennenberg H and Polle A (2010). Carbon and nitrogen balance in beech roots under competitive pressure of soil-borne microorganisms induced by girdling, drought and glucose application. *Functional Plant Biology* 37:879-889. <https://doi.org/10.1071/FP09309>