Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

PhD programme in MOUNTAIN ENVIRONMENT AND AGRICULTURE

(Curriculum 1 – Sustainable agricultural production systems)

Research projects and supervisors		
Curriculum 1 Sustainable agricultural production systems		
Title	**Supervisor(s)**	**Notes**
1. Plant-microorganism interactions and soil biodiversity **Description.** The interaction among plants, microorganisms, and soil fauna is crucial in regulating soil fertility and enhancing ecosystem resilience. This PhD project aims to investigate the influence of root exudates on microbial diversity and soil fauna, focusing on biogeochemical processes and rhizosphere dynamics. The candidate is expected to work with methodologies based on soil chemistry, environmental DNA (eDNA), and metagenomics to investigate the effect of soil composition on microbial diversity and soil fauna. The outcomes will provide novel insights to promote sustainable soil management and, more broadly, soil health. **Required knowledge:** The ideal candidate should have a solid background in soil chemistry, experience in molecular soil (agro)-ecology, and wet lab techniques. Proficiency in data analysis R environment and fieldwork experience are highly desirable.	Prof. T. Mimmo and Prof. L. Borruso	
2. Stomatal optimality in the face of climate extremes **Description**. In order to allow for the diffusion of carbon dioxide into leaves, and thus photosynthesis, vascular plants have to open their stomata, which inevitably leads to the loss of water vapor through transpiration. The photosynthetic uptake of carbon dioxide is regarded a benefit for plants, as the assimilated carbon allows for maintaining existing and growing new biomass and investing in defense and reproduction, while transpiration, conversely, is regarded a cost. It has thus been suggested that plants should adjust stomatal conductance in order to maximize the benefit of carbon sequestration, while at the same time minimizing the associated costs of transpiration and indeed, such optimal behavior has been observed experimentally and is used as a basis for modeling plant photosynthesis and transpiration. What is unknown though, is whether plants also behave	Prof. G. Wohlfahrt, Dr. A. Asensio, Prof. M. Tagliavini	

optimally when exposed to extreme climatic events, such as heatwaves or droughts. The goal of this PhD project is to investigate whether different grapevine varieties behave optimally during extreme climatic events. To that end the PhD student will conduct leaf gas exchange measurements and analyze existing prior data both from lab experiments under controlled conditions as well as field manipulations using a variety of stomatal optimality models based on different theoretical assumptions. The PhD student is expected to have a strong background in plant ecophysiology, an interest in mathematical simulation models and skills in programming and analyzing complex datasets.		
3. Assessing and certifying the safety conditions of agricultural and forestry machinery in mountainous environments **Description**. In mountainous areas, fatal tractor rollover accidents are still among the most significant risks for the agricultural and forestry sectors. Just in South Tyrol, there is an average of one fatal accident per month, and more or less serious accidents in the sector are now higher than on construction sites. In the laboratory of Agro-Forestry Innovations of unibz, located at the Bolzano Technology Park, a tilting and rotating platform with four independents, shifting platforms has been realized, capable of reproducing various conditions for extreme mountain environments and mapping the stability performance of agricultural machinery according to the environmental working conditions. The platform, unique in its kind, combines the measurement of actual rollover performance conditions with their estimation through modelling approaches, thus creating a sort of 'digital twin' that can be used for both design and certification purposes for agricultural machinery. The aim of the project is to generate 'stability maps' in the laboratory for different types of tractors (normally in use in the Alpine region) and make them available to agricultural operators driving the vehicles, so that - by means of special displays and sensors- the stability conditions can be highlighted in real time, alerting them in advance of possible increases in risk margins. In addition, since the maps are essentially based on geometric parameters (direction of advancement, inclination of the ground), for each type of tractor it will also be possible to digitally map (on GIS supports) the risk levels of the different farm areas of an agricultural or forestry company, preparing thematic maps useful for managing safety conditions according to new Smart Agriculture and Smart Forestry approaches. **Required knowledge**: We are looking for a highly motivated and collaborative PhD candidate with a background in agricultural and/or forestry sciences, rather	Prof. F. Mazzetto, Dr. G. Carabin	

than in technical domains such as mechanical, electronic or information engineering, but with a genuine and strong interest in developing a professional profile in the field of agricultural (or forestry) engineering. Candidates should have strong oral and written communication skills and a keen interest in the application of Information Technologies in the production processes carried out in the agricultural or forestry sector. Candidates should also have the ability to work in a interdisciplinary team. Past experiences with GIS platforms and programming, as well as competences in statistical data analysis and fieldwork practices, are preferential.		
4. Developing and assessing alternative niche-crop based mountain farming systems mediating between economic and environmental sustainabilty needs **Description.** Agricultural production systems in mountainous contexts have historically been characterised as activities in marginal areas, in which the economic viability of the enterprises they represent is only guaranteed by external subsidies of various kinds, the provision of which is usually motivated by political, social and economic objectives to contrast the progressive depopulation of mountains. However, support policies at the international level are destined to contract. It is therefore necessary to identify new models of agricultural development capable of responding resiliently to these trends, also by considering the adoption of new cultivation systems - often based on crops hitherto considered 'niche' - as well as facilitating the adoption of farm processing systems capable of guaranteeing greater added value than simple primary production. It is from these approaches that production chains have emerged in recent times as alternatives to those commonly adopted in alpine pastures based on the FORAGES-MILK- CHEESE transformation, and for example consisting of the sequence CEREAL-FLOUR-BREAD rather than CEREAL-MALT-BEER. In addition to these, there is also a growing interest in PISTACHO cultivation, with the associated production of high value-added dried seeds. Regardless of the solution, all these sectors have one common problem: the difficulty of managing field and post-harvest mechanisation chains in a mountainous context featured by its related environmental, economic and social issues. In particular, for certain operations (e.g. cereal harvesting on sloping terrain), the difficulties take on such constraining aspects as to make consideration of the cereal chain practically unfeasible. The aim of the project concerns: 1) a critical analysis of mechanisation problems for alternative supply chains to animal production, with particular attention also to the logistics of the production and distribution chain; 2) the	Prof. F. Mazzetto, Dr. G. Carabin	

performance of field tests on machine prototypes previously made to overcome mechanisation problems; 3) the execution of comparative and integrated analyses of supply chains, through methods that include both environmental assessment through LCA and multi-criteria analysis (AMC). In carrying out this work, we will have the opportunity to interact both with the farmers of the companies involved, and with the local institutional actors interested in assessing all the possible impacts on the territory. **Required knowledge**: We are looking for a highly motivated and collaborative PhD candidate with a background in agricultural sciences, rather than in technical domains such as mechanical, electronic or information engineering, but with a genuine and strong interest in developing a professional profile in the field of agricultural engineering. Candidates should have strong oral and written communication skills and a keen interest in the introduction of technological innovation (including digitalisation and Information Technologies) in the production processes of the mountain agricultural sector. Candidates should also have the ability to work in a interdisciplinary team. Past experiences with CAD and GIS platforms, as well as competences in statistical data analysis and fieldwork practices, are preferential.		
5. Identifying and editing genes for drought resistant apple trees. **Description**. Apple and grapevine are the main crops grown below 1500 m a.s.l. in South Tyrol. Domesticated apple varieties are grown on dwarfing rootstocks that are highly sensitive towards low water availability. Future climate scenarios with more intense and prolonged drought periods, necessitate improving drought resistance in apple trees to ensure apple production and improve water use efficiency. However, drought tolerance is a complex trait, relying in part on root system architecture adaptations, whose genetic mechanisms are largely unknown in apples. This project aims to apply a translational approach, in order to identify candidate genes with a role in root system architecture adaptations towards water stress in apple. Our goal is to obtain molecular details of water stress adaptation in apple, and to develop drought resistant rootstock for apple cultivation through genome editing. **Key words:** Drought resistance, root system architecture, genome editing **Required knowledge**: We are looking for a highly motivated and collaborative PhD candidate with a background in agricultural science, biology or molecular biology. Candidates should have strong oral and written communication skills and a keen interest in molecular biology	Dr. S. J. Unterholzner, Dr. T. Letschka, Prof. T. Mimmo	Project co-funded by the Research Centre Laimburg

with an advanced understanding for plant development and physiology. They should have the ability to work in a interdisciplinary team. Experience with molecular cloning, imaging and bioinformatic approaches are preferential.		
6. Host-parasitoid Interaction: Molecular characterization and biological role of non-hatched parasitic wasps in stink bug egg masses **Description**. The research project is part of the long-term monitoring of the effects of the release of the parasitoid *Trissolcus japonicus* on the Asian Stinkbug (*Halyomorpha halys*) and native stink bug species in South Tyrol. The main objective is to evaluate the parasitisation efficacy of *T. japonicus*, evaluating both its impact on the target population and potential effects on non-target species through host-parasitoid interactions. The invasion of *H. halys* has caused severe damage to Italian crops since 2004, with its presence documented in South Tyrol since 2019. Traditional control methods (physical barriers, insecticides and pheromone traps) have proved insufficient, leading to the start of a national release programme of *T. japonicus* in 2020. Field monitoring of stink bug eggs revealed the presence of closed eggs, raising questions about the presence of parasitoids unable to complete their development. Although, these parasitoids may still contribute to biological control, their identification is important for accurately assessing the effectiveness of the programme and specificity of the biological control agent. This project aims to explore molecular methods for the identification of parasitoid species within closed eggs. Furthermore, the analysis of interactions between hosts and parasitoids, both autochthonous and allochthonous, will contribute to the understanding of the ecological dynamics and impact of exotic insect introduction. In the long term, the results may be applied to agroecosystem management, supporting the monitoring of *T. japonicus* and other parasitoids, to optimise biological control strategies. **Keywords**: *Trissolcus japonicus*, *Halyomorpha halys*, Biological control, Host-parasitoid interactions, Molecular ecology **Required knowledge:** We are looking for an enthusiastic candidate with a background in agricultural or biological sciences, bioinformatics, ecology and evolution. Competences with molecular genetic methods as well as experience with ecological studies and field work are desired. The candidate should have excellent communication skills and should be fluent in English.	Prof. H. Schuler	Project co-funded by the Research Centre Laimburg

7. Monitoring carbon fluxes and drought impacts on alpine biomes by high-resolution time-series of vegetation biophysical variables from multi-sensor Earth Observation data. **Description.** The PhD aims to improve the estimation of biophysical variables of alpine vegetation from Earth Observation (EO) data and will contribute to quantifying the interdependent effects of climate change on vegetation productivity and health. The first objective of the PhD is to generate and validate a time-series of biophysical variables (biovars, including mainly leaf area index and fraction of absorbed photosynthetically active radiation) as a proxy for vegetation productivity and health using EO. Spatially and temporally consistent, cloud-free time-series of biovars are necessary for long-term evaluations at the regional scale and will be obtained by exploiting synergies between various sensors onboard EO satellites. In particular, the PhD will use optical sensors with different spatial and temporal resolutions, and SAR sensors which are not affected by atmospheric conditions. To fuse multi-sensor data, tailored machine learning-based techniques will be developed, also addressing the challenges deriving from the highly heterogeneous land cover and complex terrain of the Alps. The second objective is to exploit the newly developed biovars timeseries for two concrete case studies, in synergy with running projects of the Institute for Earth Observation: 1) estimating the terrestrial carbon sinks in South Tyrol to guide policymakers in decisions about greenhouse gas emissions to limit global warming, and 2) quantifying changes in vegetation productivity and consequent yield losses to inform risk management instruments and mitigate the consequences of droughts for farmers, with a focus on mountain grasslands. The PhD will work in close collaboration with the Biosphere and Hydrosphere research group of the Institute for Earth Observation of Eurac Research (M. Castelli, C. Notarnicola), which focuses on monitoring and modeling spatial-temporal dynamics of the terrestrial water cycle, vegetation conditions, and land cover in mountainous regions, leveraging Earth Observation (EO) data in physical and data driven models. The PhD will benefit from the ongoing collaboration between Eurac Research and the research groups of Prof. Tagliavini and Prof. Zanotelli at the University of Bolzano, as well as Prof. G. Wohlfahrt at the University of Innsbruck. This collaboration complements Eurac Research competences with a solid background on plant physiology and agrometeorology, which is crucial for the validation and interpretation of biophysical variables derived from EO data against in situ measurements, as well as for effective use of	Dr. M. Castelli, Dr. C. Notarnicola, Prof. D. Zanotelli, Prof. M. Tagliavini	Project co-funded by EURAC Research

EO-derived biophysical variables for estimating carbon fluxes from different biomes in South Tyrol. **Required knowledge:** the ideal PhD candidate should demonstrate: i) a solid understanding of the primary remote sensing techniques currently used for vegetation monitoring, ii) experience in handling geospatial data and pre-processing remote sensing data, particularly from optical sensors, iii) proficiency in at least one programming language (R or Python) and familiarity with GDAL, iv) a good knowledge of the main biomes characterizing the Province of Bolzano, v) expertise in techniques for measuring in situ vegetation biophysical variables, and vi) excellent written and oral English skills.		
8. Assessing the potential of traditional agroforestry systems to contribute to agricultural transformation in the context of climate change **Description.** The PhD project aims to improve the understanding of the multiple ecological and socio-economic benefits and values of traditional agroforestry systems (TAS) and their potential to contribute to successful agricultural transformation, particularly in the context of climate change and the current biodiversity loss. Specifically, the project will be developed around two main objectives: The first objective is to better understand the potential of TAS as good practice examples for biodiversity conservation in agriculturally dominated landscapes. This will include the identification of key ecological and biological indicators, and the in-field monitoring of different functional groups (i.e. plants, insects/pollinators and birds) that are widely used in agro-ecological research as key proxies for ecosystem functions and services. The second objective is to generate quantitative and qualitative evidence on the role and potential of TAS as Nature-based Solutions (NbS) towards successful agricultural transformation. This will include the assessment and mapping of several material and non-material ecosystem services (ES), and the initiation of a stakeholder engagement process finalized at a comprehensive understanding of the enabling and hindering factors that can stabilize or trigger shifts in farming practices. The regional focus of the project will be set on South Tyrol (Northern Italy), with traditional orchard meadows (GER. Streuobstwiesen) as the case study agroforestry system. **Keywords:** climate change, biodiversity loss, transformation, adaptation, ecosystem services, stakeholder engagement. **Required knowledge**: the ideal PhD candidate should demonstrate: i) proven experience in biological monitoring	Dr. L. Egarter Vigl and Prof. D. Zanotelli	Project funded by EURAC Research

and stakeholder engagement processes; ii) familiarity with the concepts of Agroforestry, Nature-based Solutions (NbS) and Ecosystem Services (ES); iii) solid knowledge of spatial analyses and Ecosystem Services modelling; iv) good knowledge of the main biomes and landscapes characterizing the Province of Bolzano; v) very good interpersonal and collaborative/organizational skills to integrate into an international working group, vi) excellent communication skills in Italian and English, German is an advantage. The PhD project will be broadly embedded in an international setting as part of the EU Biodiversa+ project TRANSFOrm (Traditional agroforestry systems as Nature-based Solutions (NbS) to face multiple societal challenges), where Eurac Research is a partner in a consortium consisting of seven partner institutions and six case studies across Europe (IT, ES, PT, AT, IL, LT). On a more practical level, the project will be implemented in close collaboration with the Landscape Ecology and Biodiversity research groups of Eurac Research's Institute for Alpine Environment (L. Egarter Vigl & M. Anderle), which focuses on monitoring and modelling the spatio-temporal dynamics of biodiversity, ecosystem services and land use change in mountain regions, mainly using both quantitative and qualitative research approaches. The PhD will benefit from the collaboration between Eurac Research and the research groups of Prof. Zanotelli at the University of Bolzano and Prof. M. Dainese at the University of Verona. This collaboration complements Eurac Research's competences with a solid background in plant physiology and sustainable agro-ecological practices, which is crucial for identifying the values and benefits of biodiversity and ecosystem services, as well as for engaging with a wide range of local and national stakeholders.		
9. Factors influencing the outbreak of the Woolly apple aphid **Description**: The woolly apple aphid (Eriosoma lanigerum) is a significant pest on apple. These aphids feed on the plant's phloem and are significantly weakening infested trees. The infestation by the woolly apple aphid and the limited control strategies poses major challenges in apple production. Significant differences in woolly apple aphid infestation densities within and between orchards suggest that numerous unknown factors are influencing the spread and infestation density of this insect. This project aims to identify factors that play a role in the infection dynamics of the woolly apple aphid through systematic surveys in practical orchards. We will conduct a comprehensive multifactorial analysis to understand factors which are influencing the outbreak of the woolly apple aphid. This project will be conducted in collaboration with the	Prof. H. Schuler	Project funded by Alpoma

Research Centre Laimburg and the Südtiroler Beratungsring für Obst- und Weinbau as well as by marketing organizations, which also ensure financing and provision of farm-related information. **Keywords**: pest insects, wooly apple aphid, plant health, multifactorial analysis. **Required knowledge**: The candidate should be capable of performing complex data analyses and should have statistical skills to analyze and interpret comprehensive results, should have in-depth knowledge in soil science, plant physiology, and biotic and abiotic factors influencing plant health, should be willing to work intensively on-site in apple orchards and conduct laboratory analyses. The candidate should be able to clearly and precisely communicate research findings and should be able to collaborate in an interdisciplinary team.		