

Syllabus

Course Description

Course Title	Experimental methods and data analysis in Agricultural and Environmental Research
Course Code	46095
Course Title Additional	
Scientific-Disciplinary Sector	NN
Language	English
Degree Course	PhD Programme in Mountain Environment and Agriculture - Major in Sustainable Agricultural Production Systems
Other Degree Courses (Loaned)	PhD MEA -
Lecturers	Prof. Massimo Tagliavini, Massimo.Tagliavini@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/209 Prof. Damiano Zanotelli, Damiano.Zanotelli@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/18696 Prof. Luigimaria Vittorio Borruso, luigimaria.borruso@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/30124 Prof. Dr. Camilla Wellstein, Camilla.Wellstein@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/33786 dr. Maria Dolores Asensio Abella, MariaDolores.AsensioAbella@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/45187 Dr. PhD. Federico Ferraccioli, Federico.Ferraccioli@unibz.it https://www.unibz.it/en/faculties/agricultural-environmental-food-sciences/academic-staff/person/45187

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Teaching Assistant	
Semester	Not defined
Course Year/s	1
CP	5
Teaching Hours	31
Lab Hours	19
Individual Study Hours	75
Planned Office Hours	15
Contents Summary	Introduction to the course; Data distribution. Error types. Dependent and independent variables; quantitative and qualitative factors; fixed and random factors; Experimental designs for agricultural sciences. Introduction to R. Data exploration. Data representation. Student's t Test; Student's t Test; Introduction to linear models; one- and two-ways ANOVA: assumptions, data transformation. Post-hoc test for multiple comparisons. Linear mixed models: Analysis of repeated measurements in time and space. Analysis of split-plot designs and nested models. Analysis of Covariance. Simple linear regression and correlation, multiple regression, breaking point analysis. Penalized models: loss plus penalty framework, bias–variance trade-off, cross-validation. Ridge and lasso regression. Generalized additive models and spatial smoothing. Introduction to machine learning: prediction vs inference; random forests and boosting; variable importance; spatial cross-validation. Experimental designs for environmental sciences. Non-parametric test and non-parametric post-hoc tests. Principal component analysis of communities. Alpha, beta and gamma diversity. Cluster analysis. Principal Coordinate Analysis (PCA). Principal component analysis of communities (PCoA). Non-metric Multi Dimensional Scaling (NMDS). Permutational

	multivariate ANOVA (PERMANOVA). Introduction into the statistical analysis of non-experimental data (e.g., surveys). Introduction into advanced regression and related analysis (e.g., structural equation modelling, propensity score matching)
Course Topics	Module 1 - Introduction to the course; Data distribution. Error types. Dependent and independent variables; quantitative and qualitative factors; fixed and random factors; Experimental designs for agricultural sciences. Module 2 - Introduction to R. Data exploration. Data representation. Module 3 - Student's t Test; Introduction to lineal models; ANOVA: assumptions, data transformation, one- and two-ways. Post-hoc test. for multiple comparisons. Missing data. Linear mixed models: Analysis of repeated measurements in time and space. Analysis of split-plot designs and nested models. Introduction to the analysis of covariance. Module 4 - Least-squares linear regression; coefficient of determination and correlation; F-statistic and p-value; breakpoint analysis; linear model diagnostics; multiple linear regression. Module 5 - Penalized models: loss plus penalty framework, bias–variance trade-off, choice of the penalty by cross-validation. Ridge and lasso regression. Generalized additive models (GAM) and spatial models. Module 6 - Introduction to machine learning: prediction vs inference. Regression trees, random forests and boosting. Variable importance. Spatial cross-validation. Module 7 - Experimental designs for environmental sciences. Nonparametric test and non-parametric post-hoc tests. Module 8 - Alpha, beta and gamma diversity. Cluster analysis. Principal Coordinate Analysis (PCA). Principal component analysis of communities (PCoA). Non-metric Multi Dimensional Scaling (NMDS). Permutational multivariate ANOVA (PERMANOVA). Module 9 - Introduction into the statistical analysis of nonexperimental data (e.g., surveys): cross-sections, time series and panel data analysis.
Keywords	Experimental designs, data exploration, data analysis
Recommended Prerequisites	Descriptive statistics Basic knowledge of R

Propaedeutic Courses	
Teaching Format	frontal lessons and exercises
Mandatory Attendance	Compulsory
Specific Educational Objectives and Learning Outcomes	Knowledge and understanding Knowledge and understanding of main concepts and statistical methods for agricultural and environmental research. Applying knowledge and understanding Ability to choose the most suitable statistical approach to be used for tackling statistical problems in agricultural and environmental sciences. Ability to check the requisites a dataset should possess to become suitable for statistical analysis. Making judgements Ability to choose the most suitable statistical approach to be used for tackling statistical problems. Communication skills Ability to prepare graphs and tables using outcomes from statistical analysis. Learning skills. Ability to autonomously adapt the methods and tools to tackle novel statistical questions also taking advantage of the open-source software "R".
Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	Students must complete class assignments on teaching modules, which will prove the students' command on statistical procedures using R.
Evaluation Criteria	Skills in critical thinking. Ability to choose suitable statistical approaches. Ability to correctly choose the statistical model and

	to understand the results of a statistical analysis
Required Readings	Handouts of the material presented and R scripts made available to the students.
Supplementary Readings	Gomez, K.A. and Gomez, A.A. (1984) Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley and Sons, New York, 680 p. Onofri A. 2025. Field Research methods in Agriculture An introduction with R. Springer <i>James, G., Witten, D., Hastie, T. and Tibshirani, R. (2021) An Introduction to Statistical Learning with Applications in R. 2nd Edition, Springer, New York, 607 p. freely available online at https://www.statlearning.com/</i>
Further Information	Students are required to install Rstudio software on their computer RStudio (https://posit.co/download/rstudio-desktop/). R ("The R Project for Statistical Computing" at https://www.rproject.org
Sustainable Development Goals (SDGs)	Quality education