RESEARCH METHODOLOGY AND PROJECT PLANNING
The general concept of research and experimentation

- **Science** = an independent, detached and objective observation of the world
- **Science** = a learning process for analyzing and understanding nature and the environment
  - Empirical sciences - developmental science and research
  - Classificatory sciences – historical and descriptive sciences
- **Research** = a cognitive system, applying different approaches and methods for answering the questions during the learning process.
- **Research** = the search for knowledge or as any systematic investigation to establish facts
  - **Agricultural science and research** = systemic science (=influences its own subject area)
Basic terminology of experimentation

- **Hypothesis** = a theory, a proposed explanation for an observable phenomenon. A hypothesis cannot be explained with the available scientific theories. From the Greek "to suppose."
- **Experiment** = used for testing the validity of the hypothesis
- **Experimental unit** = an entity that receives a treatment
- **Treatment** = a process of modifying or altering something, and depending on context may be used in an unqualified form to refer to the following: the levels of treatment factor(s) applied - variables controlled by the scientist
- **Factor** = experimental variables, controllable condition (e.g. irrigation, sowing date, fertilization etc.)
- **Experimental error** = differences/deviation in the results of treatments
- **Replication** = the repetition of the treatment (required for statistical analysis)
- **Randomization** = random arrangement of treatments to experimental unit (for avoiding systematic error)

Most common terms used for several types of **experiments**: studies, trials, surveys, analyses
Approaches in agricultural research - methods used in experiments

MAJOR STEPS of the RESEARCH PROCESS

- Problem – question - hypothesis
- Planning
- Designing
- Conducting
  - Collecting data
  - Analysing results
- Data interpretation and evaluation

NEW KNOWLEDGE
Major steps in the research process (outer circle) and corresponding sections of a scientific paper (inner circle)

Source: Malmfors et al. (2000)
Data collection and processing from scientific literature

- **Literature and data collection from printed materials** - libraries
- **Data collection** from the ISI Web of Science
  - *Primary literature in research journals* - original research articles. Review articles reporting specific results relevant to your study. *Review articles* are particularly useful = they summarize all the research done on a narrow subject area over a brief period of time.
- A **literature review** is a body of text that aims to review the critical points of current knowledge including substantive findings as well as theoretical and methodological contributions to a particular topic.

**IMPORTANT**

- Literature reviews are [secondary sources], do not report any new or original experimental work.
- Avoid citing general background references (encyclopedias, textbooks, lab manuals, style manuals, etc.) as "common" knowledge on the topic.
Data analysis

- Analytical methods of experiments
  - Qualitative research
  - Quantitative research

- **Qualitative research** = a study conducted in a natural setting where the researcher, an instrument of data collection, gathers words or pictures, analyzes them inductively, focuses on the meaning of participants, and describes a process that is both expressive and persuasive in language.

- **Quantitative research** =
  - Laboratory analyses – selected parameters for the topic, in order to test the validity of the theory/hypothesis
  - Experiments carried out under variable conditions: biological and chemical methods
  - In the **social sciences**, **quantitative research** refers to the systematic empirical investigation of **quantitative properties** and **phenomena** and their **relationships**.
Analysis and data interpretation, use of statistical methods

- A wide range of specific methods and approaches, depending on the discipline and research topic.

**EXAMPLES**
- Single-, two- and multi-factor analyses of results
- Regression and correlation analyses
- Results of laboratory determinations are commonly analysed by using computer program packages e.g. SPSS, most commonly ANOVA (ANalysis Of VAriance) test is conducted.
- Results are compared to untreated/unfertilized control, significant differences ($\text{LSD}_{5\%}$) or correlation between determinant factors (coefficient values, $r$ or $R^2$) are expressed.
Experimental Design Process

1) Define Problem(s)
2) Determine Objectives
3) Brainstorm
4) Design Experiment
5) Conduct Experiment & Collect Data
6) Analyze Data
7) Interpret Results
8) Verify Predicted Results

Steps of the Scientific Method

1. Make observations.
2. Ask a question.
3. Form a hypothesis.
4. Test the hypothesis.
5. Analyze the results.
6. Draw conclusions.
7. Communicate the results.
Cell line replicates

Bad example

Better

None of these are biological replicates - but we do the best we can.
Example (Experimental Design)

Experimental design (assuming a completely randomized design) to test the question “does the presence of the ‘useless’ second option of $125 print subscription affect how people choose between the first option of $59 web subscription and the third option of $125 print and web subscription?” for The Economist.

200 MIT Students → Random Assignment

Group 1: 100 MIT Students

Treatment 1: Survey WITH “useless” option

Compare Proportions

Group 2: 100 MIT Students

Treatment 2: Survey WITHOUT “useless” option