Reverse
EUROPEAN PROJECT
TO PRESERVE BIODIVERSITY

First Interregional Seminar REVERSE
« Agriculture and Biodiversity »
Bordeaux, 23/25 June 2010

BEST PRACTICE PRESENTATION

Action

MICROBIAL BIODIVERSITY AS BIOINDICATOR OF THE IMPACT OF AGRICULTURAL PRACTICES ON SOIL HEALTH

Partner: Basque Government

Body implementing the action: **NEIKER – Basque Institute of Agricultural Research and Development (neiker.net)**

Location: Basque Country (Biscay)

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European Union
European Regional Development Fund

EUSKO JAURLARITZA
GOBIERNO VASCO

Background

AGRICULTURE IS THE HUMAN ACTIVITY THAT HAS TRANSFORMED MOST OF THE EARTH

MAIN DRIVERS OF GLOBAL CHANGE

- ***Land use change***
- ***Climate change***
- ***Pollution***
- ***Biodiversity loss***
- ***Nitrogen deposition***
- ***Invasive organisms***

Global change is the term used to encompass a multitude of environmental and ecological changes that have been noticed, measured and studied on Earth at a global scale

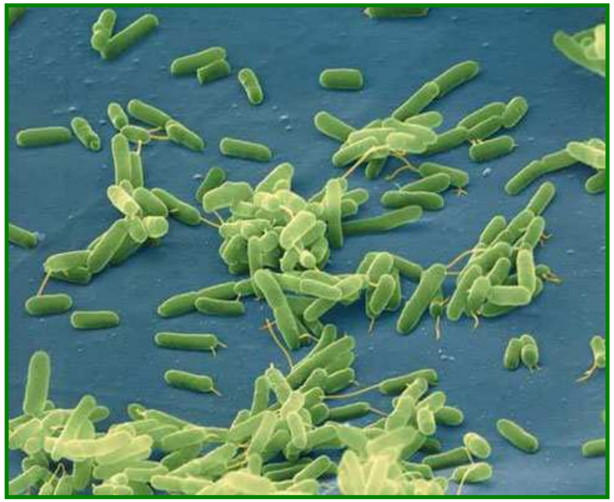
Background

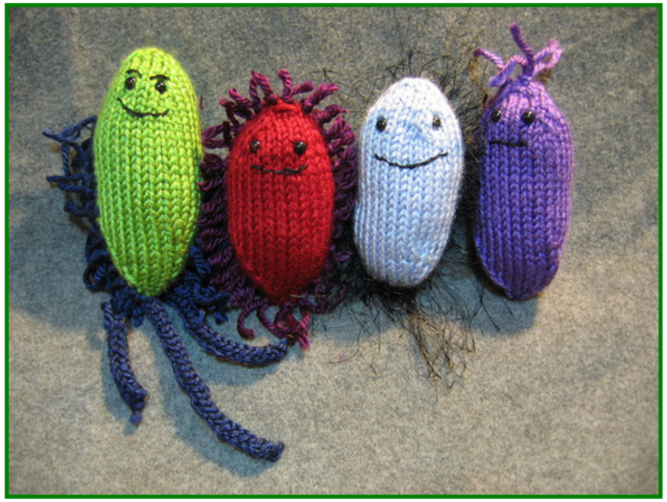
MICROORGANISMS ARE THE MOST IMPORTANT ORGANISMS IN THIS PLANET

Regarding their importance to the functioning of the Earth system, the ecologically most important group are the prokaryotes followed by the single-celled eukaryotes and then the fungi and plants. The least important group is the animals

In addition to moral reasons to preserve it for its own sake, biodiversity provides numerous ecosystem services that are crucial to human well-being

MICROORGANISMS ARE INVOLVED IN MOST OF THOSE ECOSYSTEM SERVICES





Vital role in the main processes of our planet:

- **Photosynthesis**
- **Nitrogen fixation**
- **Decomposition of OM**
- **Nutrient cycling**

Background

MICROORGANISMS ARE THE MOST IMPORTANT ORGANISMS IN THIS PLANET

HUMANS

Only 1/10th of the cells in a human body are human, 9/10th are microbes

1,000 species in our mouths
1,000 species in our guts
500 species on our skins

10% of our dry weight consists of bacteria

The vast majority of the genes in our body are not human

Microbes make up more than one half of the Earth´s biomass (probably much more: >80%)

MICROORGANISMS IN THE SOIL ECOSYSTEM:

- ► **80% of the total biomass**
- ► **2-6 tonnes per hectare**
- ► **4 million species in a ton of soil**
- ► **< 0.1-1% are cultivable**
- ► **Natural soil: 3,000-10,000 species g^{-1}**
- ► **Agricultural soil: 140-350 species g^{-1}**

Belowground biomass: similar (slightly higher) to that aboveground

Belowground biodiversity: several orders of magnitude higher to that aboveground

"To study biodiversity in this planet and not to consider microbial biodiversity, is like studying the human cardiovascular system and not to include the heart"

GOALS AND TARGETS

1) To study the impact of conventional agricultural practices on soil health using a variety of soil microbial properties

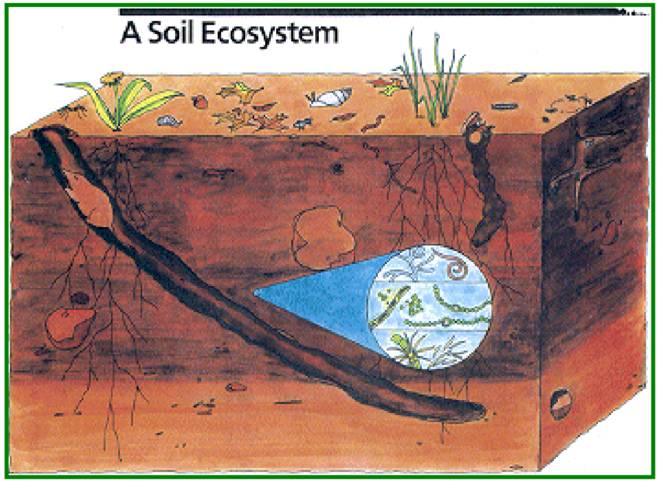
2) To study the beneficial effects of more sustainable agricultural practices on soil health using a variety of soil microbial properties

3) To use SOIL MICROBIAL BIODIVERSITY as biological indicator of soil health

4) To develop soil health cards as a tool to bridge the gap between farmers, decision-makers and scientists

SOIL HEALTH: the capacity of a given soil to perform its functions and ecosystem services

- **Provision of food (medium for plant growth), fibre and fuel**
- **Decomposition of organic matter (recycling of nutrients)**
- **Storing and filtering of water**
- **Habitat for many organisms and reservoir of genetic biodiversity**
- **Detoxification of contaminants**
- **Carbon sink (agricultural soil: emission of greenhouse gases)**
- **Etc.**



METHODOLOGY

HUMAN RESOURCES

SOIL MICROBIAL ECOLOGY GROUP at NEIKER:
1 group leader, 4 postdocs, 2 PhD students

FINANCIAL RESOURCES

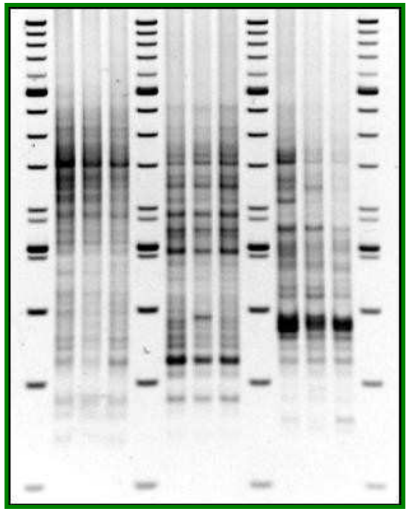
Several reseach projects in the last 10 years funded by:

- The Basque Government
- The Biscay County Council
- The Spanish Government

METHODOLOGICAL TOOLS

MICROBIAL BIOMASS
- Microbial biomass C
- ATP
- DNA-biomass
- Substrate-induced respiration
- Q-PCR: functional groups
- Total and easily extractable glomalin
- Cultivable heterotrophs

MICROBIAL ACTIVITY
- Basal respiration
- Mineralizable N
- Nitrification rate
- Denitrification
- Methanogenesis
- Enzyme activities

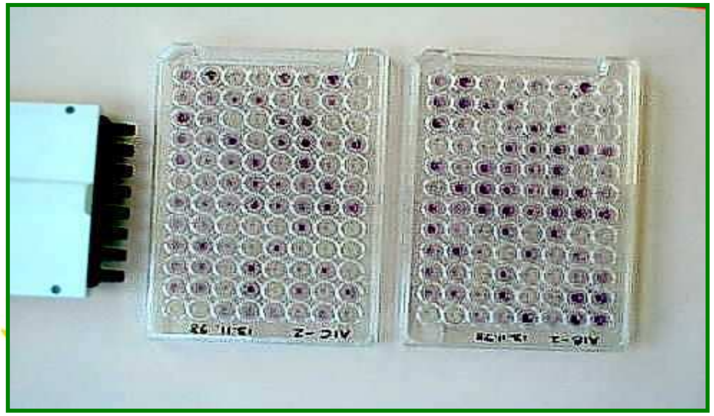


MICROBIAL BIODIVERSITY: community-level profiles

FUNCTIONAL BIODIVERSITY: community-level physiological profiles with BIOLOG plates

STRUCTURAL AND FUNCTIONAL BIODIVERSITY: community-level genetic profiles with PCR-DGGE (taxonomic and functional groups: ammonia-oxidizers, chitin-degraders, denitrifiers, etc.), DNA-microarrays, genetic profiles through reciprocal hybridization

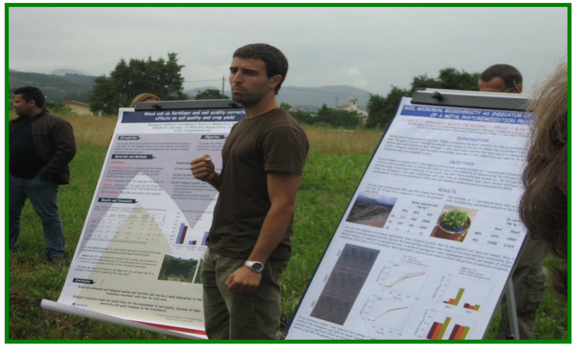
RESPONSE BIODIVERSITY: stability (resistance and resilience) essays



OTHER TOOLS
- Gene expression (RNA) levels
- Soil suppressiveness

TEACHINGS OF THE ACTION

On a regular basis, workshops are organized to transfer the knowledge to farmers, decision-makers, scientists, etc.



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RESULTS: SOME RECENT RELEVANT PUBLICATIONS

● Mijangos I, Albizu I, Epelde L, Amezaga I, Mendarte S, Garbisu C (2010) Effects of liming on soil properties and plant performance of temperate mountainous grasslands. **Journal of Environmental Management** (in press)

● Mijangos I, Garbisu C (2010) Consequences of soil sampling depth during the assessment of the effects of tillage on soil quality: a common oversight. **Soil and Tillage Research** (in press)

● Mijangos I, Albizu I, Garbisu C (2010) Beneficial effects of organic fertilization and no-tillage on fine-textured soil properties under two different forage crop rotations. **Soil Science** 175: 173-185

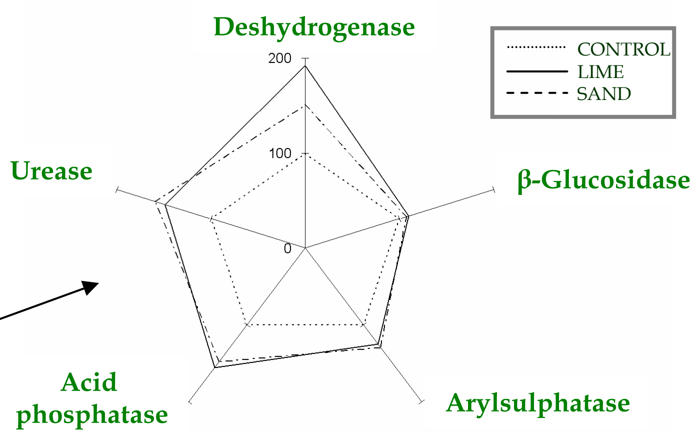
● Mijangos I, Becerril JM, Albizu I, Epelde L, Garbisu C (2009) Effects of glyphosate on rhizosphere soil microbial communities under two different plant compositions by cultivation-dependent and -independent methodologies. **Soil Biology and Biochemistry** 41: 505-513

● Mijangos I, Pérez R, Albizu I, Garbisu C (2006) Effects of fertilization and tillage on soil biological parameters. **Enzyme and Microbial Technology** 40, 100-106

For more publications, please see webpage of the SOIL MICROBIAL ECOLOGY GROUP – NEIKER (http://www.neiker.net/neiker/soil.html)

RESULTS: Impact of liming products in grasslands

LIME
versus
CALCAREOUS SAND
versus
WOOD ASH

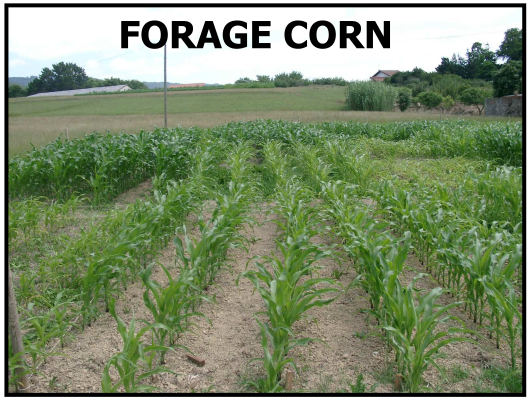


$$T-SQI=10^{\log m+\frac{\sum_{i=1}^{n}(\log n_i-\log m)-\sum_{i=1}^{n}\left|\log n_i-\log \bar{n}\right|}{n}}$$

NEW SOIL QUALITY/HEALTH INDEX

The soil microbial functional diversity (catabolic diversity: capacity of the soil microbial community to utilize different C substrates) slightly decreased in lime-amended soils

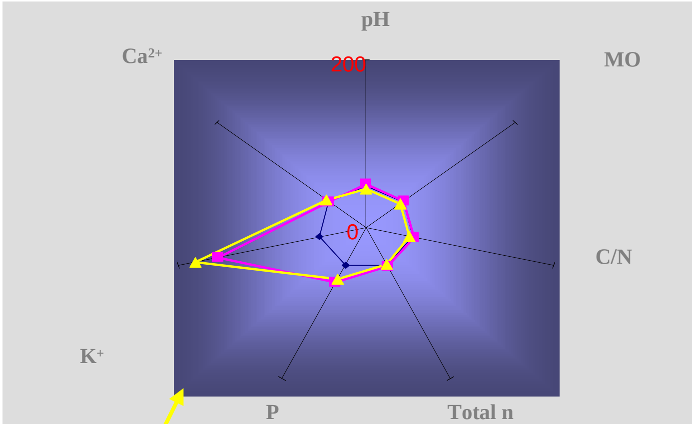
RESULTS: Impact of fertilization and tillage in intensive rotations



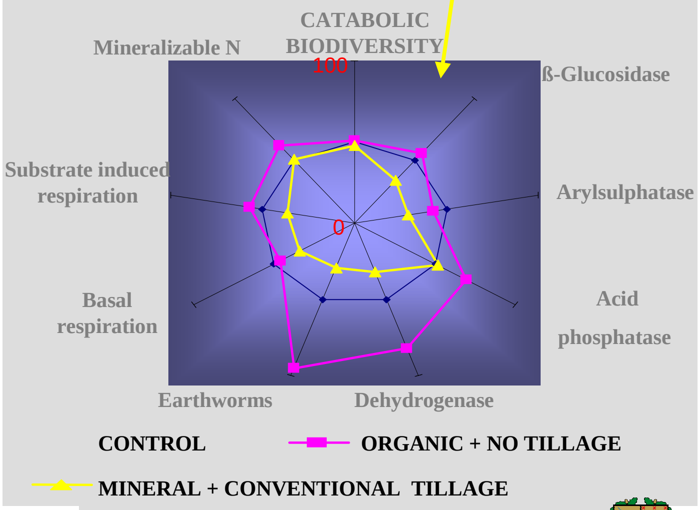
NO-TILLAGE
versus
CONVENTIONAL TILLAGE

ORGANIC FERTILIZATION
versus
MINERAL FERTILIZATION

MICROBIOLOGICAL PROPERTIES ARE MORE SENSITIVE THAN CONVENTIONAL PHYSICOCHEMICAL PROPERTIES



CHEMICAL INDICATORS *versus* BIOLOGICAL INDICATORS



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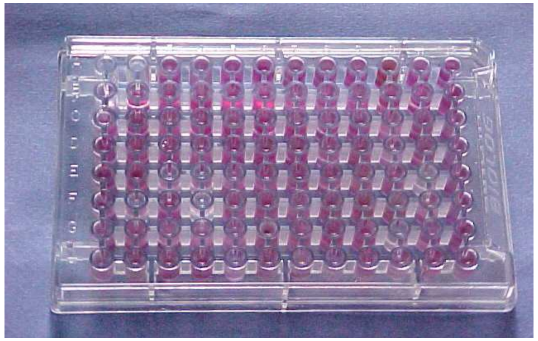
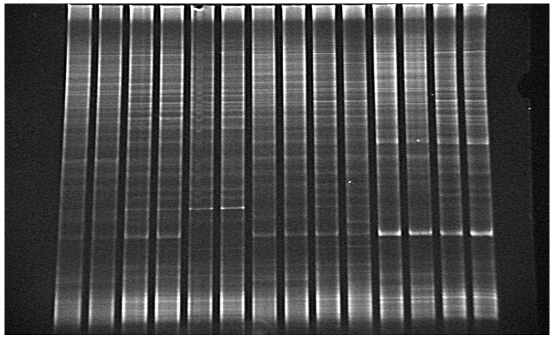
RESULTS: Impact of herbicides (glyphosate)

Catabolic diversity using Biolog Ecoplates[R]

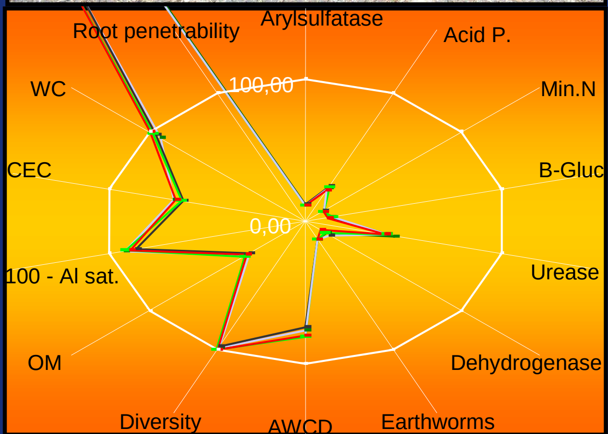


	Nitrogen mineralizable	NH_4^+-N	BIOLOG AWCD	BIOLOG S	BIOLOG H'	DNA-DGGE DNA biomasa	DNA-DGGE S	DNA-DGGE H'
				TRITICALE				
Control (0 glyphosate)	21.8^{A}	4.7^{A}	1.33^{A}	30.0^{A}	3.22^{A}	4.03^{A}	23.7^{A}	2.95^{A}
50 mg kg^{-1} glyphosate	32.6^{A}	10.8^{A}	**0.79^{B}**	**27.3^{B}**	**3.05^{B}**	3.97^{A}	23.7^{A}	3.01^{A}
500 mg kg^{-1} glyphosate	36.0^{A}	26.2^{B}	**1.07^{C}**	30.7^{A}	3.20^{AB}	4.41^{A}	23.0^{A}	2.93^{A}
				TRITICALE + PEA				
Control (0 glyphosate)	20.8^{A}	7.9^{A}	1.33^{A}	30.7^{A}	3.24^{A}	3.93^{A}	25.7^{A}	3.08^{A}
50 mg kg^{-1} glyphosate	**37.4^{B}**	23.6^{B}	**1.05^{B}**	30.7^{A}	3.25^{A}	2.93^{A}	23.3^{A}	2.97^{AB}
500 mg kg^{-1} glyphosate	**47.4^{B}**	47.0^{C}	**1.03^{B}**	**28.7^{B}**	3.17^{A}	3.43^{A}	22.0^{A}	2.90^{B}

Genetic diversity using DNA-DGGE electrophoresis



Beneficial effects of sustainable agricultural practices in degraded agricultural soils



	Control	NT+O	CT+O	NT+I	CT+I
A-SQI	100	12.7	12.7	12.7	12.7

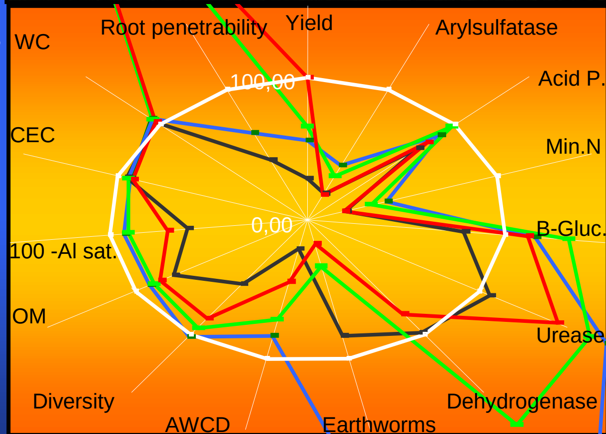
AFTER 4 YEARS

A-SQI IMPROVED UNDER ALL MANAGEMENTS

NO-TILLAGE (NT) GREATLY ENHANCED DEHYDROGENASE ACTIVITY AND EARTHWORMS ABUNDANCE, BUT CAUSED SOIL COMPACTION

SLURRY (O) INCREASED ENZYME ACTIVITIES, MICROBIAL DIVERSITY AND ALLEVIATED SOIL ACIDITY

NT+O LED TO HIGHEST A-SQI
CT+I PRODUCED THE HIGHEST MAIZE YIELD
NT-I LED TO THE LOWEST YIELD AND A-SQI



	Control	NT+O	CT+O	NT+I	CT+I
A-SQI	100	59.8	55.1	25.0	56.1

ENVIRONMENTAL FITNESS **ECONOMIC FITNESS**

$$A-SQI = 10^{\log m + \frac{1}{2}\left[\frac{\sum_{i=1}^{n}(\log n_i - \log m) - \sum_{i=1}^{n}\left|\log n_i - \log \bar{n}\right|}{n} + \log Y - \log Y_m\right]}$$

ANOTHER SOIL QUALITY/HEALTH INDEX

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FOLLOW UP: Future actions

Development of soil health cards specifically designed for our local farmers

FACT SHEETS
What is soil microbial diversity?
How can be measured?
Where can be measured?

SPECIAL EMPHASIS ON SOIL MICROBIAL PROPERTIES (MICROBIAL BIODIVERSITY)

SOIL MICROBIAL ECOLOGY GROUP

DATA INTERPRETATION ACCORDING TO SOIL USE

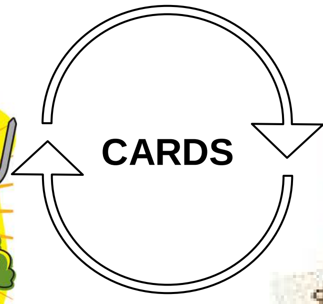
⇒ **Quantitative:** ***from 1 – 10***

⇒ **Qualitative:**
Very low value
Low value
Average value
High value
Very high value

RECOMMENDATIONS
Recommended agricultural practices to improve soil microbial diversity

DECISION MAKERS

FARMERS



SCIENTISTS

CONCLUSION

SOIL MICROBIAL PROPERTIES (IN PARTICULAR, SOIL MICROBIAL BIODIVERSITY) ARE MOST USEFUL METHODOLOGICAL TOOLS TO ASSESS THE IMPACT OF AGRICULTURAL PRACTICES ON SOIL HEALTH AND, CONCOMITANTLY, AGROECOSYSTEM SUSTAINABILITY

THANK YOU VERY MUCH FOR YOUR ATTENTION !!