



ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA



## Long-term Agronomic Trials

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(DISTAL)



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## *Cadriano Farm*

Via Gandolfi 19, 40057 Granarolo (BO, Italy)

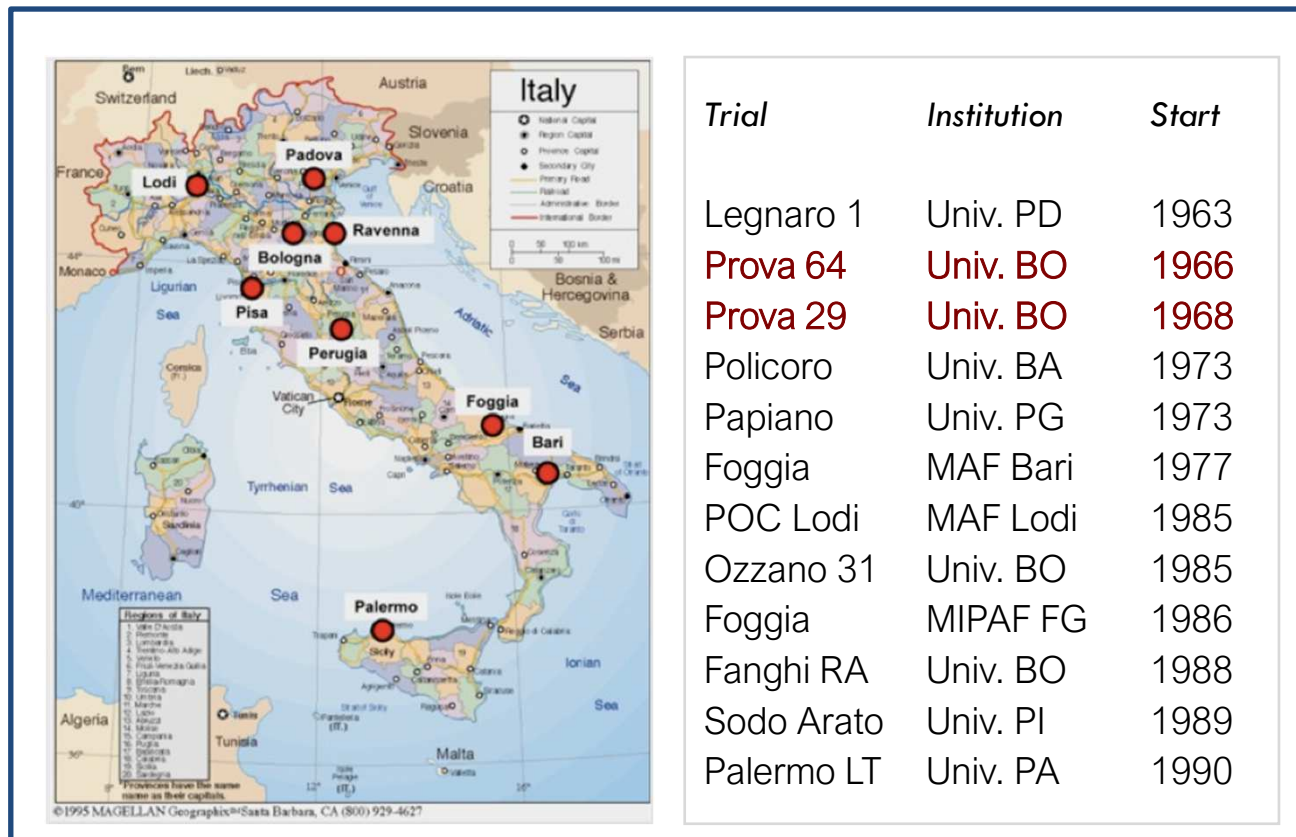
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# History

Two of the first trials established in AUB in 1966-68 are still in progress. They are the second and third oldest agronomic experiments in Italy. They are amongst the first 10 oldest replicated trials in the World.



## Responsibles



*Prof. Ettore Mancini*

Director of the former Institute of Agronomy of Bologna, in 1964 he created the Experimental Farm of Bologna University.



*Prof. Remigio Baldoni*

In 1966, he started field trials, to study crop fertilisation and rotations, as he had already done in Bari and Padua Universities.



*Prof. Giovanni Toderi*

He helped plan the first trials, then carried them on, and established other long-term experiments at the University farms.



*Prof. Guido Baldoni*

He have kept going the long-term experiments since 2006 until now



# Development

## Management

Over the years, the experiments changed slightly, with minor adjustments (e.g. *crop varieties, pesticides, ...* ), not involving the tested treatments.

This constancy is essential when:

- Slow, gradual effects are studied (e.g. soil organic matter dynamics)
- Compared practices differentiate in a long time (e.g. crop rotations)

Therefore, the trials are an invaluable resource to:

- Study slow, buffered changes in the ecosystem in the long term
- Evaluate the sustainability of cropping systems in the long term



**Aims** have changed over time:

- At first → To increase crop productivity  
(e.g. *crop yield increase, soil fertility enhancement*)
- Then → To preserve the environment  
(e.g. *soil conservation, N leaching*)
- Then → To safeguard human safety  
(e.g. *pesticide residues in food, mycotoxins in grains*)
- Then → To address social issues  
(e.g. *farmers survival, CAP check, CO<sub>2</sub> sequestration*)
- In the future → Who knows?

**Possible uses**

- Historical documentation
- Basic Research
- Applied Research
- Validation of models
- Education of students
- Extension to farmers
- Support to politicians



# The field experiments at the University of Bologna

| Trial      | Site               | Start | End  | Rotation | Inorganic fertilisation | Organic fertilisation | Soil tillage | Irrigation |
|------------|--------------------|-------|------|----------|-------------------------|-----------------------|--------------|------------|
| 307        | Carpi (MO)         | 1976  | 2000 |          | X                       |                       | X            |            |
| 30         | Molinella (BO)     | 1978  | 2000 |          | X                       |                       | X            |            |
| 31         | Ozzano Emilia (BO) | 1985  | 2019 | X        |                         |                       | X            |            |
| 64         | Cadriano (BO)      | 1966  |      | X        | X                       | X                     |              |            |
| 29         | Cadriano (BO)      | 1968  |      |          | X                       | X                     |              |            |
| ISDV       | Cadriano (BO)      | 1972  | 2000 |          |                         | X                     |              |            |
| 340        | Ozzano Emilia (BO) | 1981  | 2000 | X        | X                       |                       |              |            |
| 33         | Altedo (BO)        | 1983  | 2001 |          | X                       |                       |              |            |
| Gandazzolo | Baricella (BO)     | 1967  | 1995 | X        | X                       | X                     |              | X          |
| Sludge     | Ravenna (RA)       | 1988  | 2000 |          | X                       | X                     |              |            |

X Compared treatments in interactions tested in replicated split-plots

ongoing trials

## AUB – Cadriano (BO)

44°33'N – 11°24'E – 33 m a.s.l.

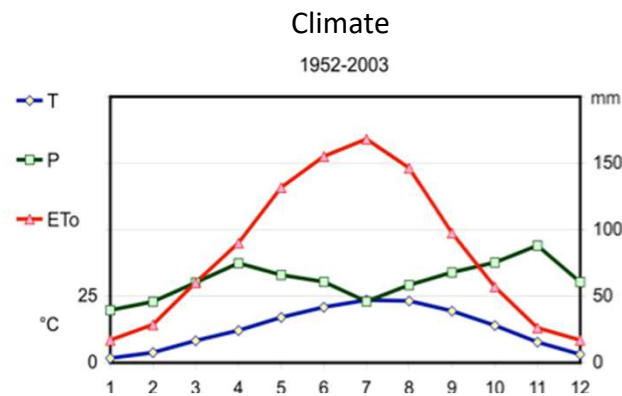


## AUB – Ozzano Emilia (BO)

44°25' N – 11°29'E – 90 m a.s.l.



## Experiments in Cadriano (1966 & 1968 → )



Soil: Fine silty mixed mesic udic ustochrepts  
Silty loam – 1.3% OM, 6.9 pH



**Trail 64.** Split-split plot with 2 replicates

### **CROP ROTATIONS**

Continuous winter wheat; Continuous maize;  
Maize – wheat; sugarbeet – wheat;  
maize-wheat-maize-wheat-maize-wheat-alfalfa-  
alfalfa-alfalfa

### **x MINERAL & ORGANIC FERTILISATIONS**

Cattle manure rates L0, L1, L2 (stopped in 1984)  
x 3 rates of NP mineral fertilizers

**Trial 29.** Split plot with 4 replicates

### **ORGANIC MATTER INCORPORATION**

Control, Crop residues, Cattle manure, Cattle slurry  
supplied each year at a same dry matter rate.

### **x N MINERAL SUPPLY**

Control, 3 urea rates

In a maize – wheat rotation



## Experiments in Cadriano (1966 & 1968 → )



**Trail 64**  
Wheat in 9-year rotation



**Trail 64**  
Continuous wheat , N0



**Trail 64**  
Continuous maize, N0



**Trail 29**  
Wheat without fertilizers



**Trail 29**  
Maize without fertilizers



**Trail 29**  
Soil sampling





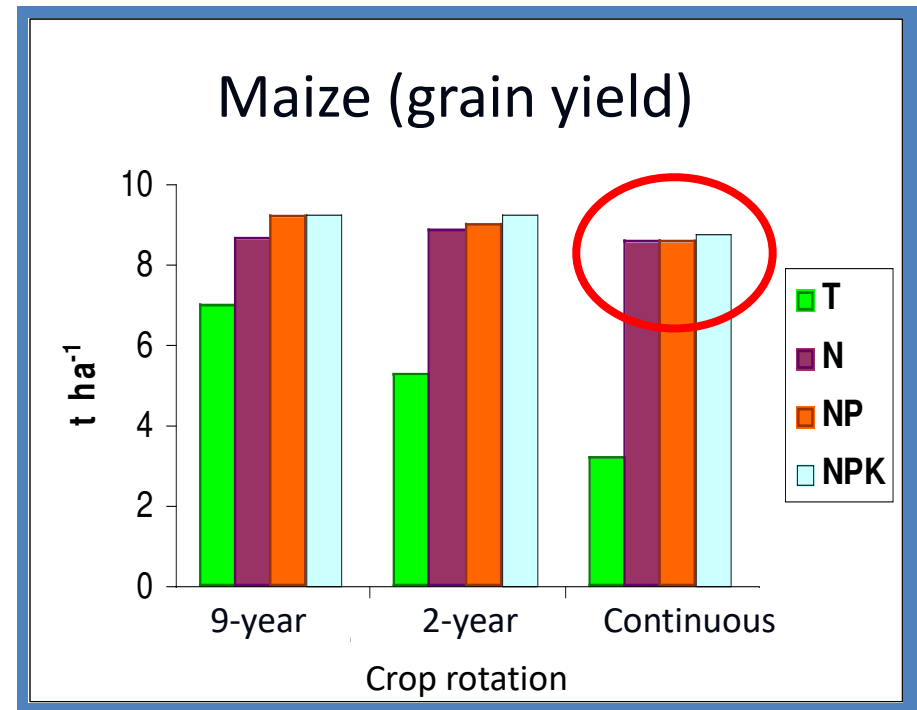
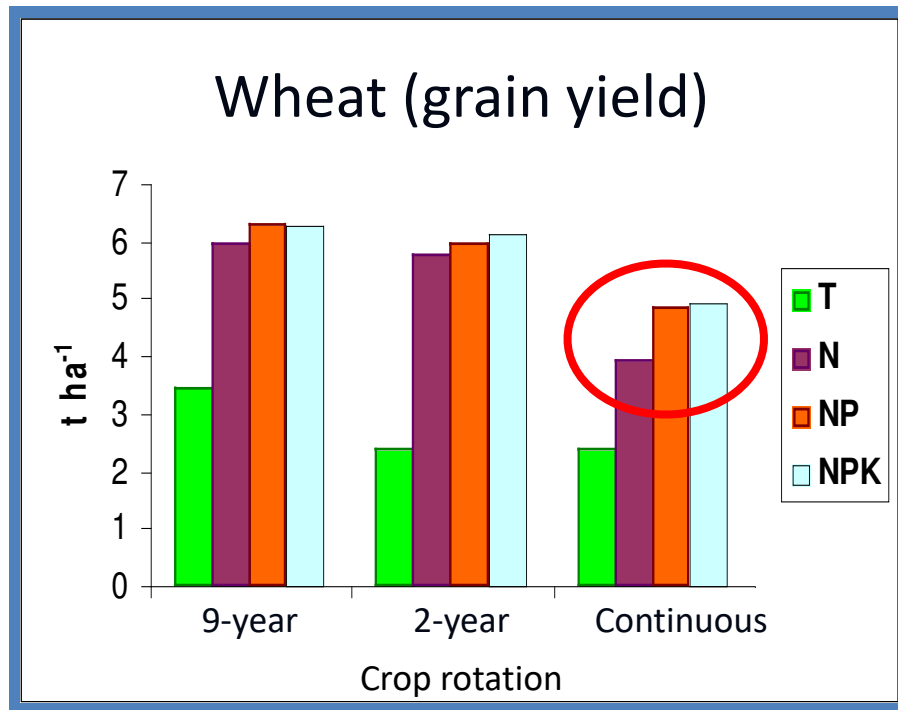
# Results for the farmers

Economic sustainability

Trail 64 – Cadriano  
(1967-2002 averages)



## Crop rotation x Mineral fertilization



Continuous maize is feasible (with an optimal mineral fertilization)  
Continuous wheat is not feasible (even with a high mineral fertilization)



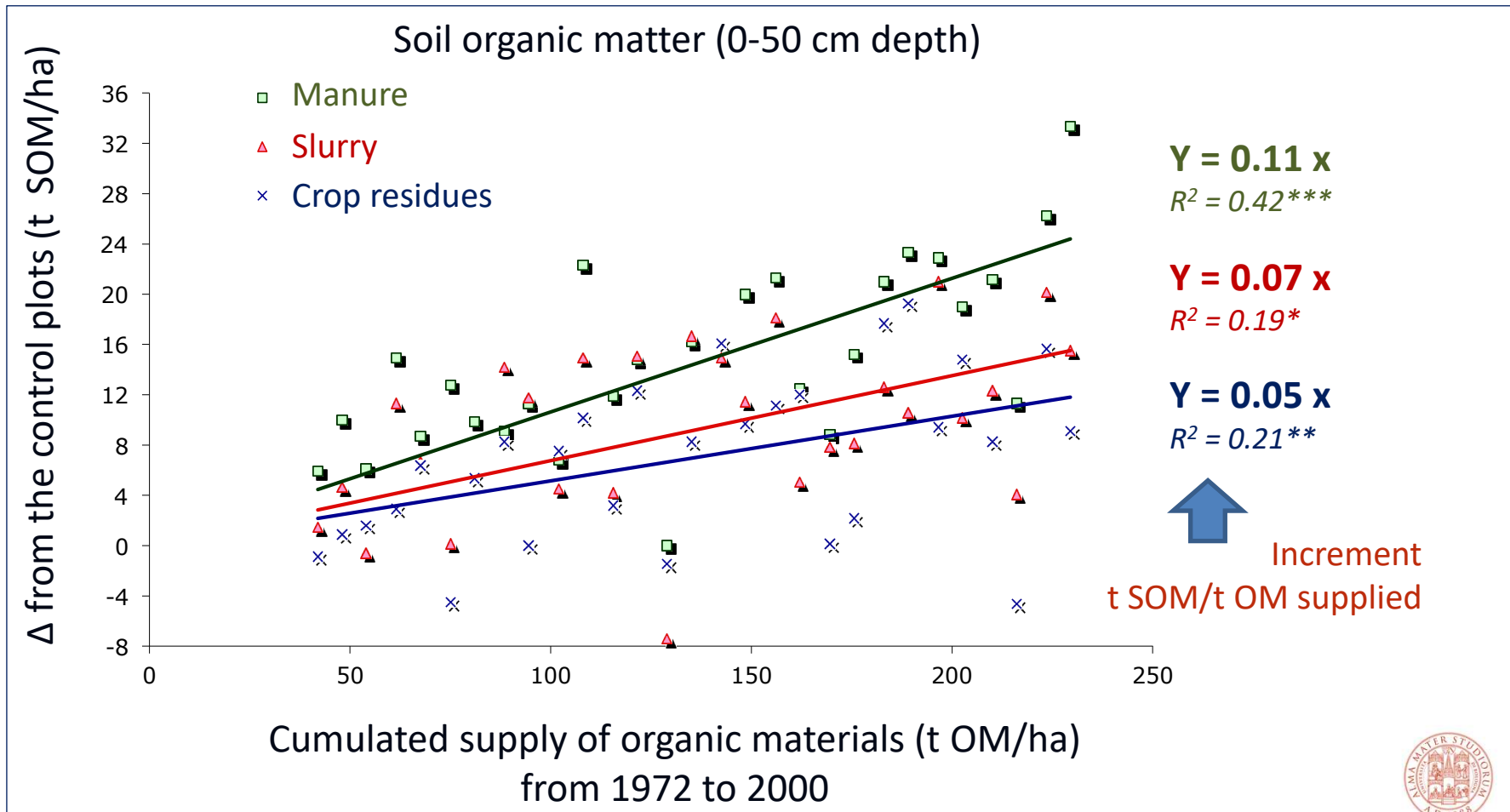
# Results for the environment



Environmental sustainability

Trial 29 – Cadriano

Tilled soil → atmospheric CO<sub>2</sub> sink (OK for Greta)



# Results for the human health



*Social sustainability*

Tilled soil = filter for toxic elements (OK for waste recycle)

| Fertilizers supplied for 18 years | Soil content (0-40 cm layer)<br>- ppm of dry Matter - |         |         |         |
|-----------------------------------|---|---------|---------|---------|
|                                   | Olsen P   | EDTA-Zn | EDTA-Cu | EDTA-Pb |
| Control                           | 34  | 108     | 79      | 24      |
| Mineral fertilizers               | 28  | 106     | 78      | 23      |
| Sludge                            | 53  | 116     | 84      | 25      |

**Sludge trial** Ravenna (1989 - 2004)



## Soil & Plant sample collection

Each year, soil (0-50 cm depth) and plant samples are collected.  
They are dried, ground, sieved and kept indoor, at Cadriano

*Total samples = 71,345*



| <b>Trial 64</b>  | <i>Since</i> | <i>To</i> | <b>Trial 29</b> | <i>Since</i> | <i>To</i> |
|------------------|--------------|-----------|-----------------|--------------|-----------|
| <i>Wheat</i>     |              |           | <i>Wheat</i>    |              |           |
| Grain            | 1967         | 2005      | Grain           | 1968         | 2005      |
| Straw            | 1967         | 2005      | Straw           | 1968         | 2005      |
| <i>Maize</i>     |              |           | <i>Maize</i>    |              |           |
| Grain            | 1968         | 2005      | Grain           | 1966         | 2003      |
| Stalk            | 1969         | 2005      | Stalk           | 1971         | 2000      |
| Cob              | 1973         | 1988      | Cob             | 1973         | 1987      |
| <i>Sugarbeet</i> |              |           | <i>Soil</i>     |              |           |
| Root             | 1968         | 2004      | from ≠ layers   | 1972         | 2002      |
| Leaf             | 1968         | 2004      |                 |              |           |
| <i>Alfalfa</i>   |              |           |                 |              |           |
| Hay              | 1967         | 2005      |                 |              |           |
| <i>Soil</i>      |              |           |                 |              |           |
| from ≠ layers    | 1972         | 2002      |                 |              |           |



# Data collection

All collected data have been input in electronic databases

In 2019 the database was made of:

**15 MB** of data relative to climatic parameters

**62 MB** of data relative to crop parameters

**68 MB** of data relative to pedological parameters

Prova condotta presso: Azienda Sperimentale della Facoltà di Agraria, Gossolengo (Bologna)

Scopo ed importanza della prova: studio degli effetti della monocoltura di: mais, della rotazione annuale grano-granturco e di miscelimi biennali: mais-grano più granturco, e biotolo-grano più granturco, nelle loro zone e nelle variazioni della fertilità del terreno. Tali miscelimi culturali sono stati messi a confronto con una rotazione biennale che prevede: mais-grano più granturco - medica - medica - medica.

Tale impostazione culturale permette di valutare, a lungo termine, gli effetti del medicare sulla fertilità del terreno e le conseguenze della sua eventuale eliminazione dall'arricchimento culturale, attraverso il confronto della biennale: mais-grano più granturco con la monocoltura in cui le stesse colture sono arricchite con medica. Tali confronti dovrebbero permettere di studiare: gli effetti della monocoltura del mais mediante il suo confronto con la rotazione in cui il mais è arricchito con il grano o con la medica come colture principali. Gli effetti di una rotazione annuale molto sfruttata (grano-granturco) confrontabile con altre in cui figura anche il mais e la biotolo o il mais e la medica; gli effetti nel terreno e l'evoluzione dei risultati economici ottenibili con il mais o con la biotolo mediante il confronto delle rotazioni: mais-grano o biotolo-grano. È ovvio che i risultati non prescindono in considerazione solamente gli aspetti produttivi e le variazioni di fertilità del terreno, ma dovranno essere compilati da considerazioni di carattere economico.

Tale è noto che il problema dell'arricchimento culturale non può essere risolto da quelle rotazioni monocolture della fertilità del terreno e che questa dipende tra l'altro dall'armonica combinazione di colture a effetto

Data are organized in standardized Excel® pages and have been used to validate several models.



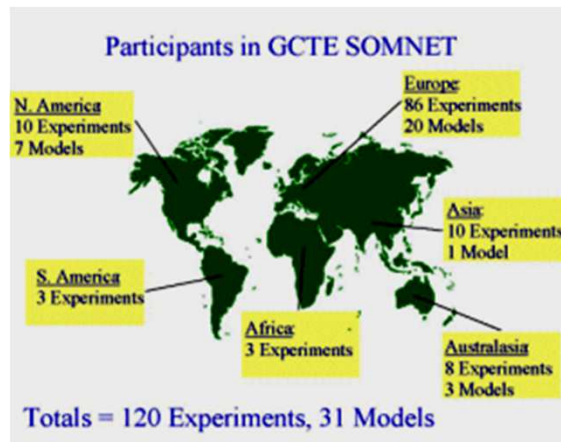
# Research networks

*Collaborations with other Italian Universities*

where long-term experiments are on course (PD, PI, PG, PA, TO, AN)

*Data exchange in international webs of long-term experiments*

- **GCTE-SOMNET** Global Change & Terrestrial Ecosystems SOM Network
- **CLIMAGRI-LT** Data Management of Agronomic Experiments
- **LTAES** Long Term Agroecosystem Experiments
- **LTSES** Long Term Soil Ecosystems studies
- **ICFAR** Linking Long Term Observatories with Crop Systems Modeling For a better understanding of Climate Change Impact, and Adaptation Strategies for Italian Cropping Systems”



## Disadvantages of long-term trials

### *High costs of the field experiments*

- High requirement of qualified and precise labour: now in Italy it is quite expensive (~ 17 €/h)

### *Very few funds from the private sector*

- Agrobusiness is not interested in basic research with little economic return

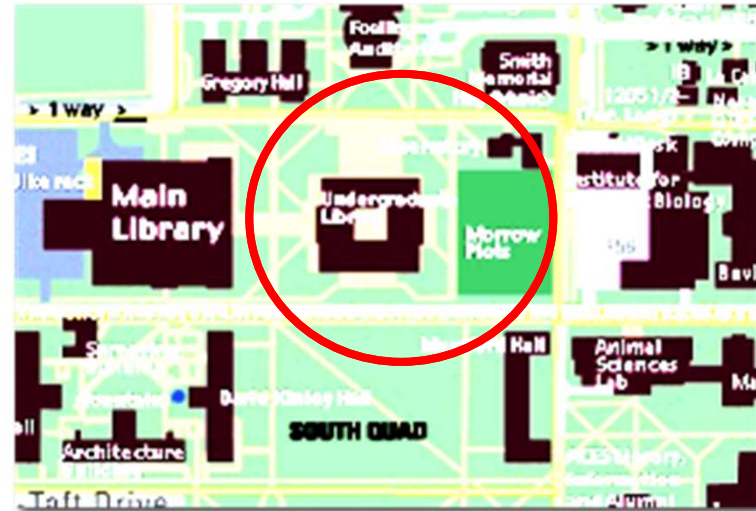
### *Long time for suitable results*

- Publishable results only after several years



# Is it that way all over the World?

Yes, It is !



Exception: USA

L.T.E. → National Historic Landmarks

*e.g.*

The Morrow Plots (Champaign, IL)

The Old Rotation (Auburn, AL)





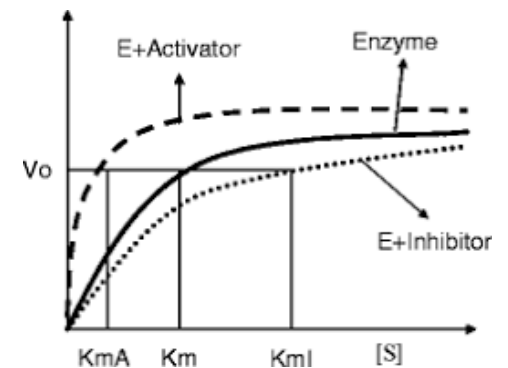
# Are long-term trials still interesting?

Up to now they have been helpful, for example, giving information on: No-tillage, mycotoxins, waste recycling, CO<sub>2</sub> sequestration, crop system modelling, mineral fertilizer rates, organic farming, ...



*The results that can be obtained are typically multidisciplinary*

Many of them regard soil environment for its slow dynamics





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