THÜNEN

# Development of phosphatase and dehydrogenase activities in soils of annual cropland and permanent grassland in an organic farm

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**Bredsten**

# Overview

1 Introduction

2 Material & methods

3 Results

Enzyme activity and

- *Land use*
- *Organic management*
- *Tillage*

4 Conclusions

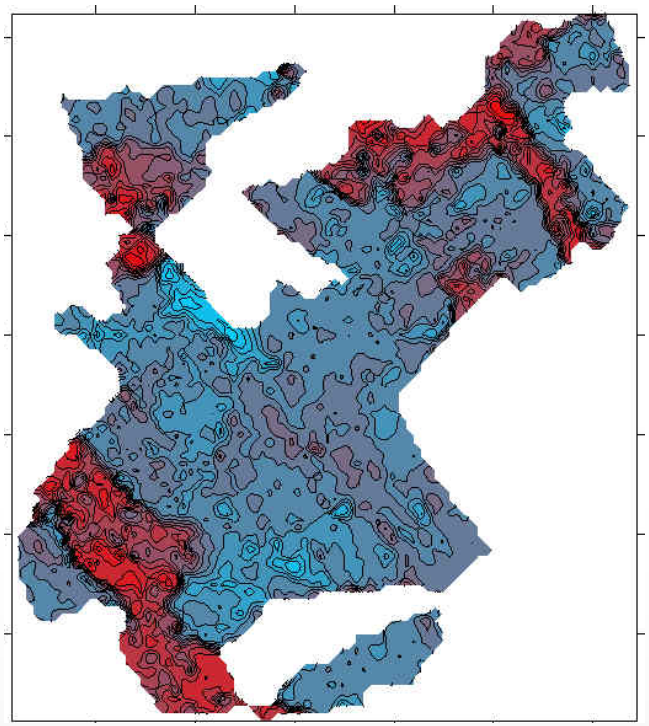
# Global availability of Phosphorus

- Phosphorus (P) is an essential element for plant nutrition
- We use it as a non-renewable resource mined from phosphate rock (possibly depleted in 50-100 years).
- We can improve P cycles in order to retain P available for farming.
- Now we focus on how to make the P that is already in the soil available to plants.

**Phosphorus mining in Morocco** Foto: Togo Infranet Lab

**Phosphorus defiency in plants** Foto: R. Stamm

# Grassland may play an important role



pH-values at the 600 ha sized research farm Trenthorst (2002):
Min 4,4 - Max 7,4

- P is present in many different forms in soil but concentrations of plant available P (inorganic P) in soil solution are typically low
- Permanent grassland shows lower pH-values than arable land
- Permanent vegetation cover promotes microbial activity
- Microorganisms possess an innate capacity to enhance P cycling in soil

# Microbial enzyme activity and P release

**Phosphatase catalyses** the hydrolysis of ester phosphate bonds, **leading to the release of phosphate** (from organic P compounds), which can be taken up by plants or microorganisms.

**Alkaline and acid phosphatases** are analyzed based on the use of *p*-Nitrophenyl phosphate (pNPP) (Tabatabai und Bremner 1969).

**Dehydrogenase activity** is one of the general criteria to determine **microbial activity in soil.**

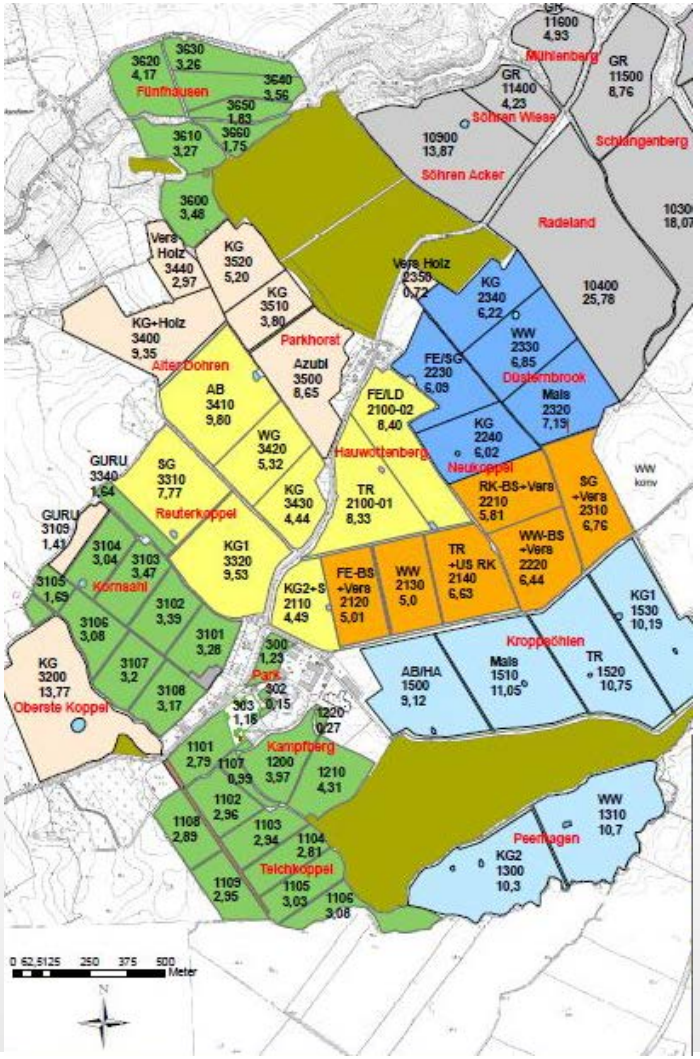
**Dehydrogenase activity** is measured based on the use of Triphenyltetrazoliumchlorid (TTC) (Thalmann 1968).

# Research questions

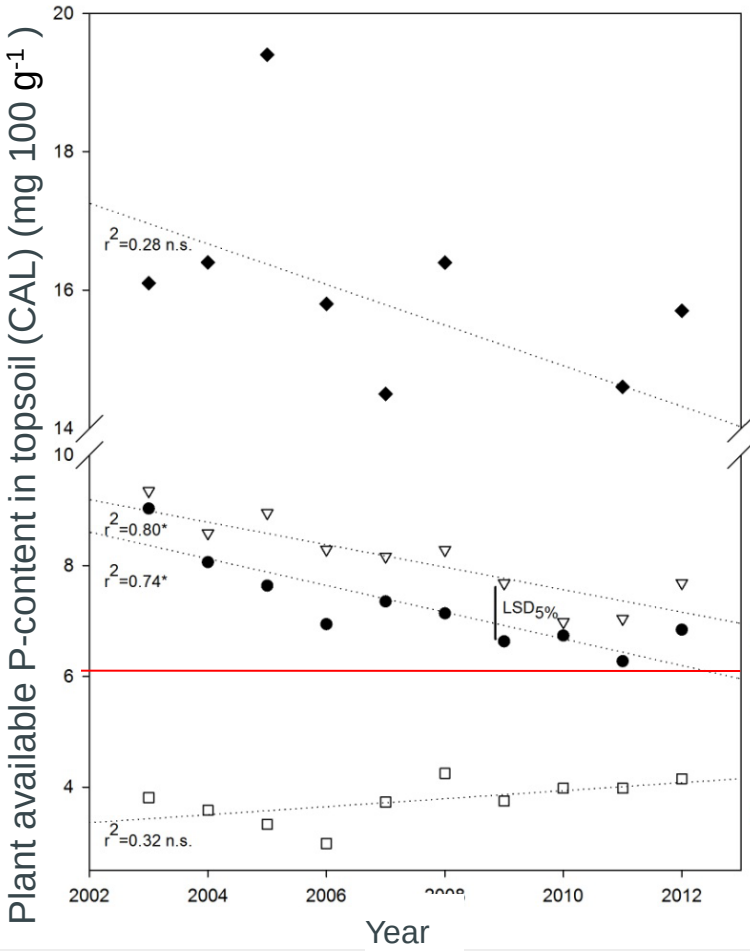
1. *Land use:* What are the differences in enzyme activity between 1) organic grassland 2) organic arable land and 3) conventional arable land?
2. *Organic management:* How did the enzyme activity change with the conversion to organic farming in 2001?
3. *Tillage:* How does tillage influence enzyme activity?
4. What kind of management system can lead to P sufficiency in organic farming?

# Research farm “Trenthorst”

- Located in Northern Germany (53°46´E, 10°30´N; 10-43m asl)
- Mean annual precipitation: 706 mm; temperature: 8.8°C
- Conversion from conventional to organic farming in 2001
- Long Term Experiment:
  - 4 different crop rotations (cash crop, dairy, goats, pigs) permanent grassland and conventional practices (close to the organic plots) are tested
  - 4 GPS-located permanent observation points per plot, soil samples 0-30 cm since 2001



# Soil properties in Trenthorst




## Characterisation: Cambisols and Luvisols

| organic | pH-value | $C_{org}$ % | Sand % | Silt % | Clay % |
|---|---|---|---|---|---|
| Grass-land | 5.5 | 2.91 | 38 | 41 | 16 |
| Arable land | 6.6 | 1.43 | 46 | 34 | 18 |


Development of plant available P-content (CAL) in topsoil of grass-land (0-10 cm) and arabale land (0-30 cm), Trenthorst (2003-2012)

# Tillage

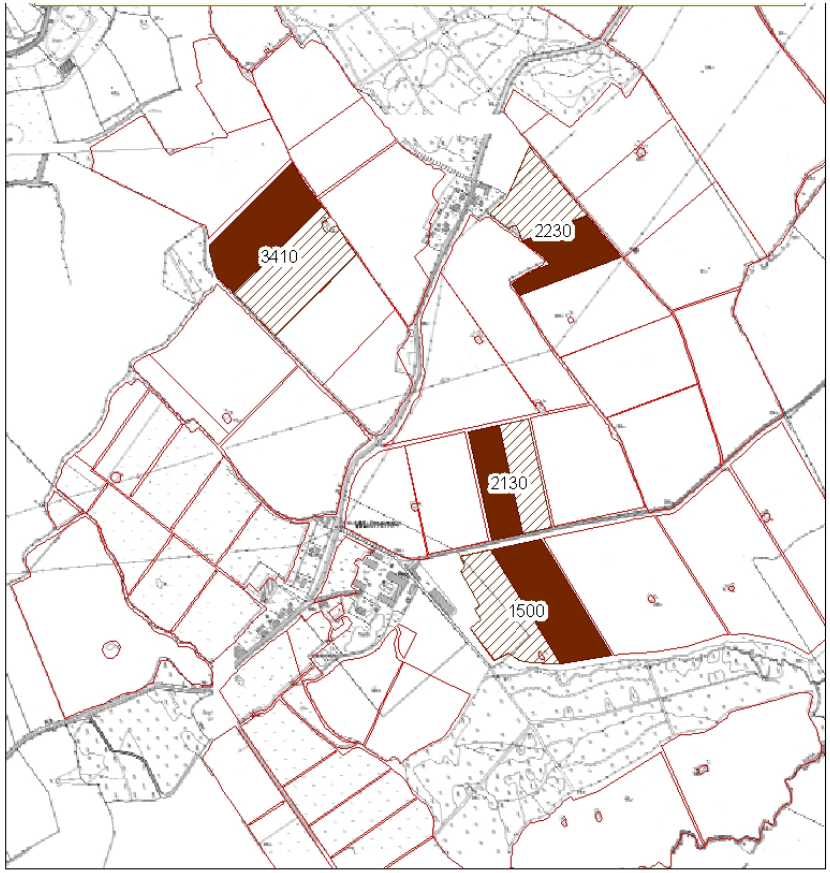
Short term experiment started in October 2012:

- One plot per crop rotation, triticale was planted on each plot
- 2 different tillage types:

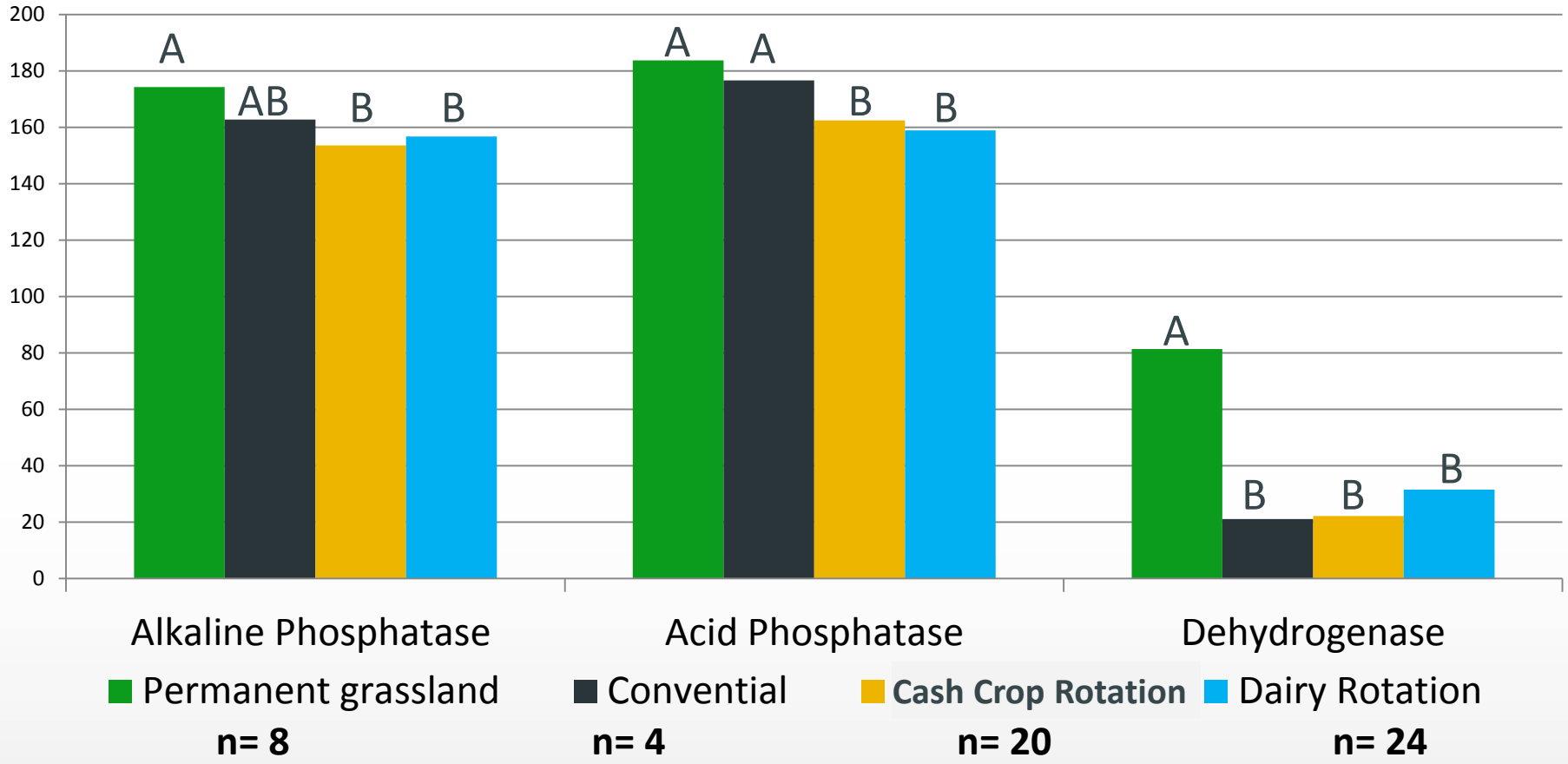
Ploughing (30 cm depth)

Reduced tillage (15 cm depth)

- 4 sample points per tillage type and plot in 2 depths: 0-15 cm and 15-30 cm

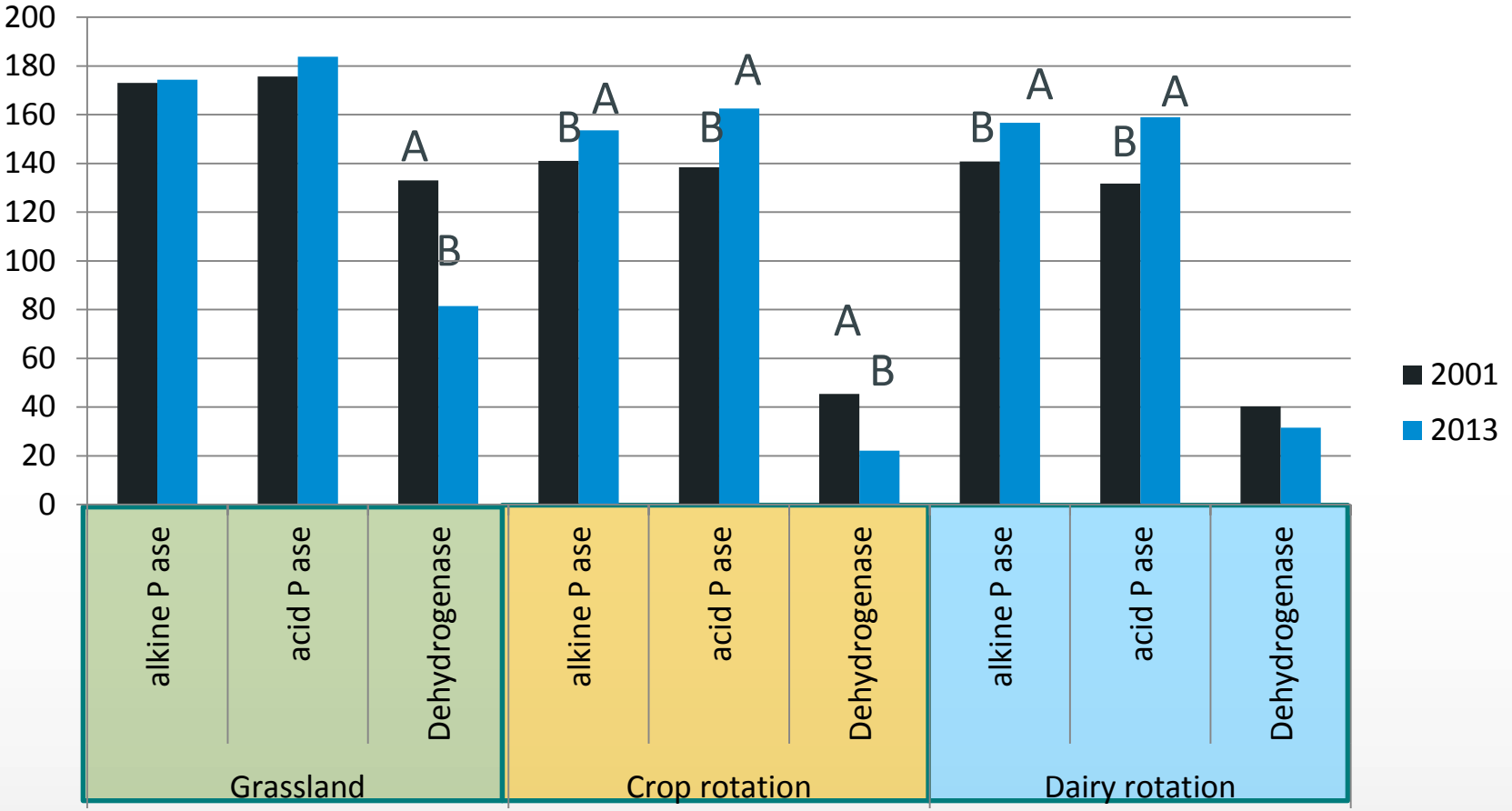


# Land use and enzyme activity



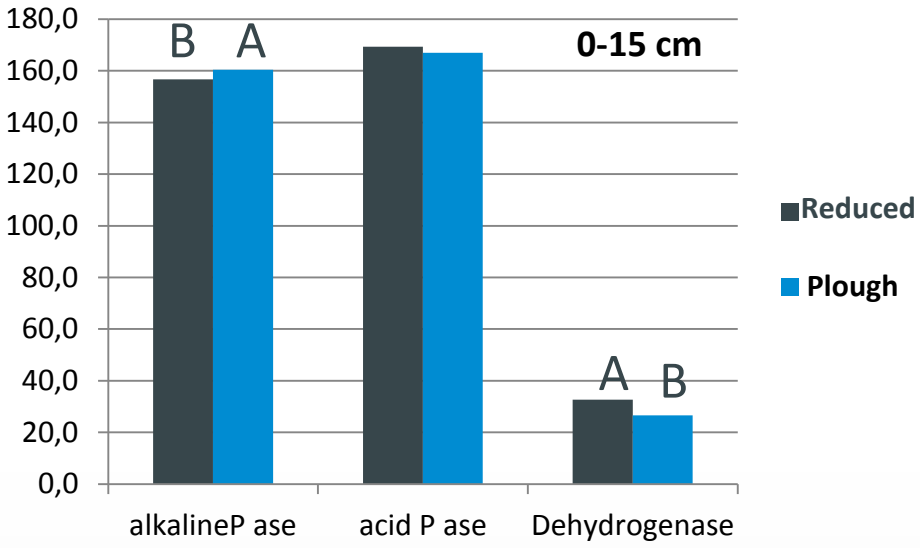

Activity of alkaline and acid Phosphatase (µg p-nitrophenol $g^{-1}$ soil $h^{-1}$) and Dehydrogenase (µg Triphenylformazan (TPF) $g^{-1}$ soil $h^{-24}$) in soils of different land use in May 2013 (0-30 cm), ANOVA: F-test p= <0.0001; comparison of mean Student t-test α= 0.05

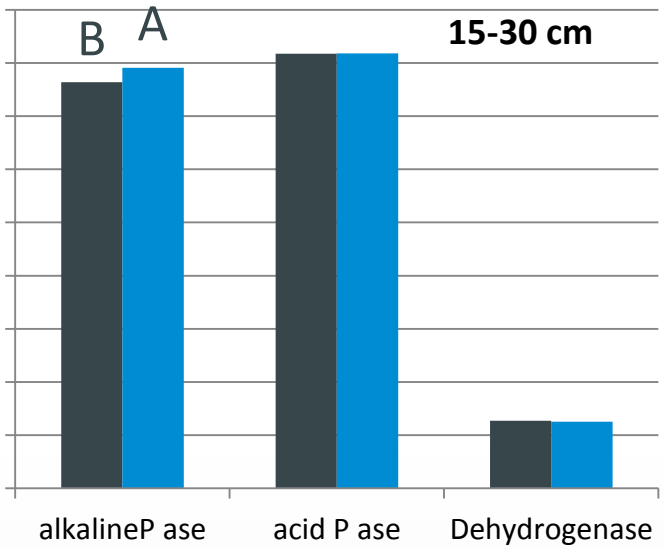
# Organic management and enzyme activity




Activity of alkaline and acid Phosphatase (µg p-nitrophenol $g^{-1}$ soil $h^{-1}$) and Dehydrogenase (µg Triphenylformazan (TPF) $g^{-1}$ soil $h^{-24}$) in soils in 2001 and 2013 after 12 years of organic farming (0-30 cm), ANOVA: F-test p= <0.0001; comparison of mean Student t-test α= 0.05

# Tillage and enzyme activity




**Activity of alkaline and acid Phosphatase (µg p-nitrophenol $g^{-1}$ soil $h^{-1}$) and Dehydrogenase (µg Triphenylformazan (TPF) $g^{-1}$ soil $h^{-24}$) in soils with ploghing and reduced tillage in May 2013 (0-15 and 15-30 cm), Student t-test α= 0.05, n= 16**

# Summary

1. Land use: Permanent grassland shows significant higher enzyme activities than arable land.
2. Organic management: Phosphatase activity increases while dehydrogenase activity decreases.
3. Tillage: Reduced tillage shows significant higher dehydrogenase activity in the 0-15 cm layer and significant lower alkaline phosphatase in the 0-15 and 15-30 cm layer.

# Outlook: Management and P sufficiency?

1. Due to the high microbial activity in organic grassland there is a high potential for P uptake by plants.
2. In-farm P flows are currently investigated in Trenthorst in order to find ways to improve P cycles.
3. In a P constrained future and in organic farming grassland might play a special role in addition to improved P cycles.

# Thank you!

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