# Structure liming and omitting ploughing as measures to reduce agricultural nutrient loading to surface waters

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Soil tillage methods to control phosphorus loss and potential side-effects: A Scandinavian review. Soil Use and Management 26, 94-107

**B. Ulén , H. Aronsson , M. Bechmann [1] , T. Krogstad [2], L. Øygarden [1] & M. Stenberg 2010**
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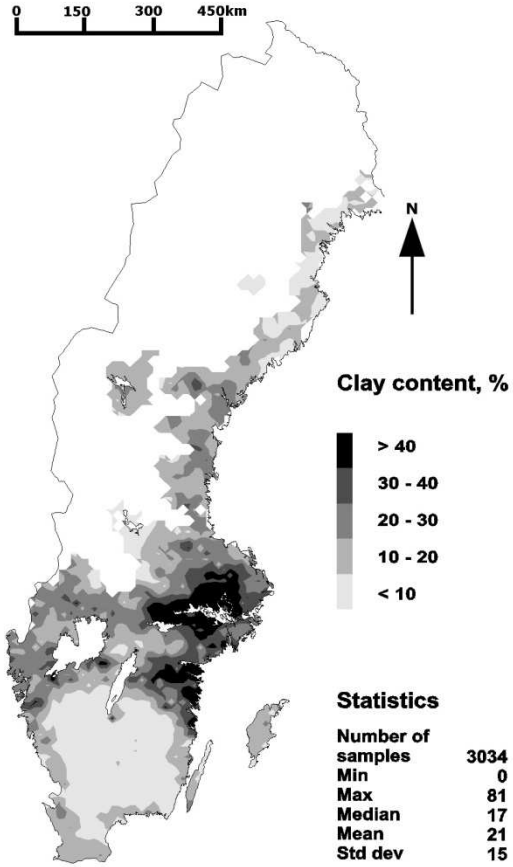
Clay soils are usually drained. By tradition, the *Clayic Cambisols* and *Stagnic Luvisols* are ploughed in autumn with mouldboard ploughing



# Soil management
## Topsoil as a filter – changes in soil hydrology - changes in soil chemistry

Structure-limed topsoil after cultivation

Omitting ploughing

# Structure liming - an old method

1) Quicklime, ‘burned lime’ CaO

2) Slaked lime, ‘hydrated lime’ $Ca(OH)_2$

Commercial available also in mixtures with common agriculture lime

# Quicklime

Immediate reaction with the surfaces of clay particles

$$\text{Clay-}2H^{+} + CaO \rightarrow \text{Clay -}Ca^{2+} + H_2O$$

- More and stronger soil aggregates
- The clay soil becomes less soapy
- The clay shrink/swell less

Earlier ploughing is possible, soil structure is preserved,
Significantly increased yields

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# Hydrated lime

Slow reaction with silicon and formation of carbonate:

1) Pozzolan reaction – formation of silicate-hydrate:

$$Ca(OH)_2 + H_4SiO_4 \rightarrow CaH_2SiO_{4*}2\ H_2O$$

2) Formation of mortar:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3$$

# Plot experiments Lanna, Västgöta plain (SW Sweden) CaO application

- Plot 1 12 tons $ha^{-1}$ 1962 + 3 tons $ha^{-1}$ 1972
- Plot 2 6 tons $ha^{-1}$ 1962 + 3 tons $ha^{-1}$ 1972
- Plot 3 3 tons $ha^{-1}$ 1962 + 3 tons $ha^{-1}$ 1972

1992-2006

Yield: Plot 1> Plot 2> Plot 3

Phosphorus leaching: Plot 1< Plot 2< Plot 3

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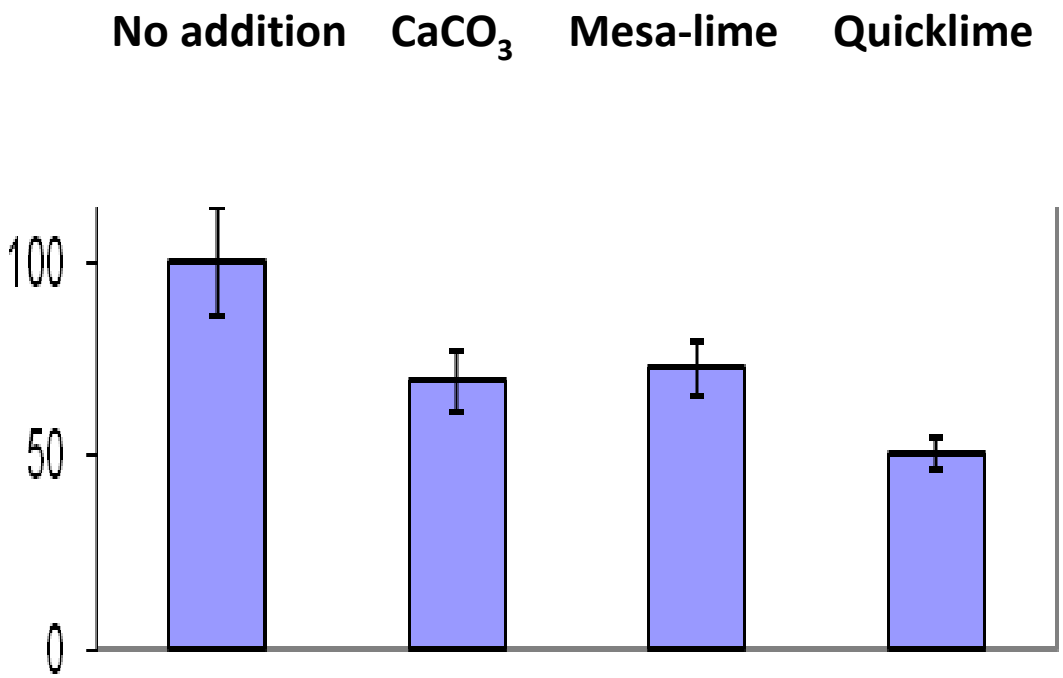
# Soil aggregate stability with different forms of lime additives to a heavy clay soil




Direct drilling - the crop is sown in a single operation with or without shallow cultivation by separate tines or discs operating in front of the drill tines.


First stubble cultivation in 30° angle
In comparison with earlier operations

Modern heavy disc cultivator


Cultivator with goose foot (left) and rigid pins (right).

# Field results from Scandinavia on soil tillage as a measure to reduce phosphorus from clay loam-clay soil (tillage without ploughing in autumn)

| Option | PP | DRP | DRP/TotP in water (%) |
|---|---|---|---|
| Direct drilling | 0.3, 0.4 | 3.5, 4.0 | 50-65 |
| Shallow cultivation | 0.4, 0.5, 0.6, 0.8, 0.9, 0.9, 0.9, 1.2, 1.3 | 0.5, 1.0, 1.3, 1.4, 1.7, 1.9, 1.9, 4.4 | 10-50 |
| Deep cultivation | 0.8, 0.9 | 1.0, 1.4 | 10-20 |

Ploughing = 1

PP on average -24% -70% - +190%;
DRP on average +200% -50% - + 400%

DRP losses without ploughing compared with conventional ploughing have increased up to fourfold in field experiments.

# Potential phosphorus leaching from different types of grass before and after freezing

**Topsoil sampling**

**Field monitoring** ⟷ **Combination** ⟷ **Laboratory measurement**

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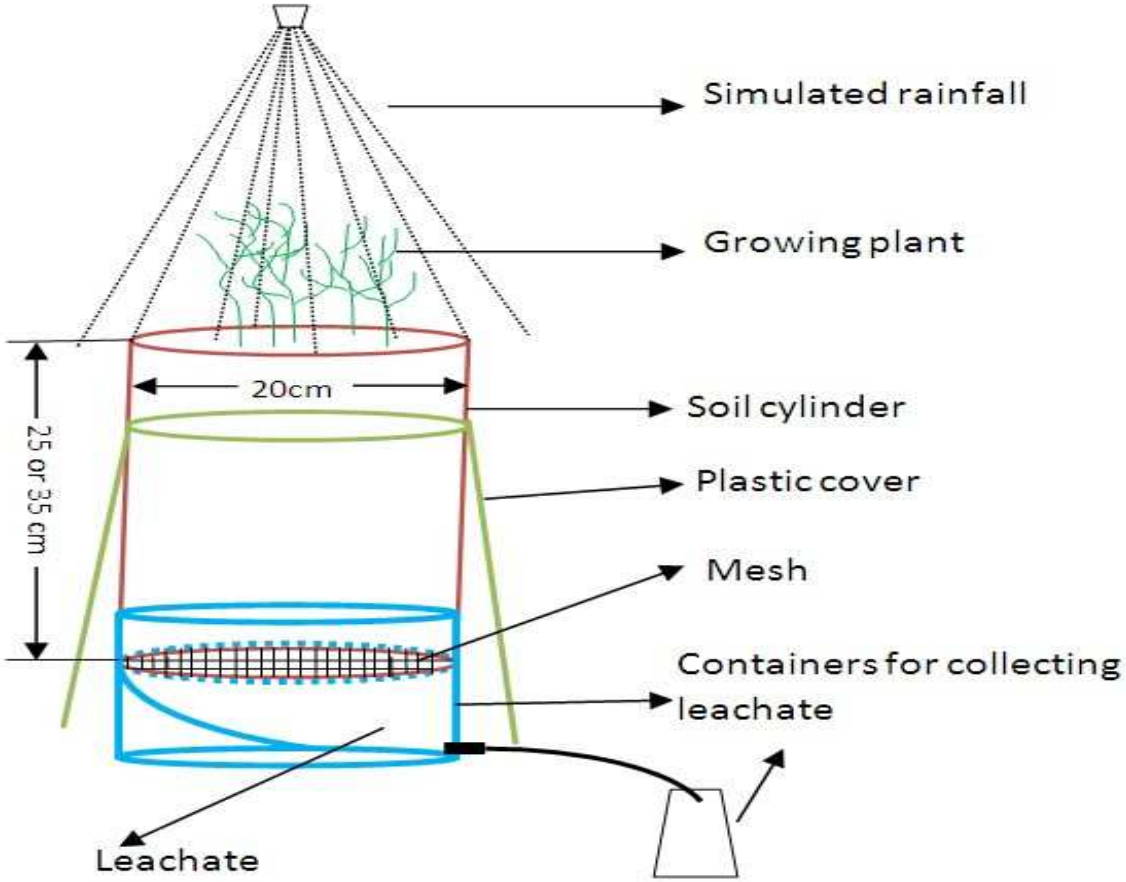
# Lysimeter equipment



## Other side-effects of omitting ploughing

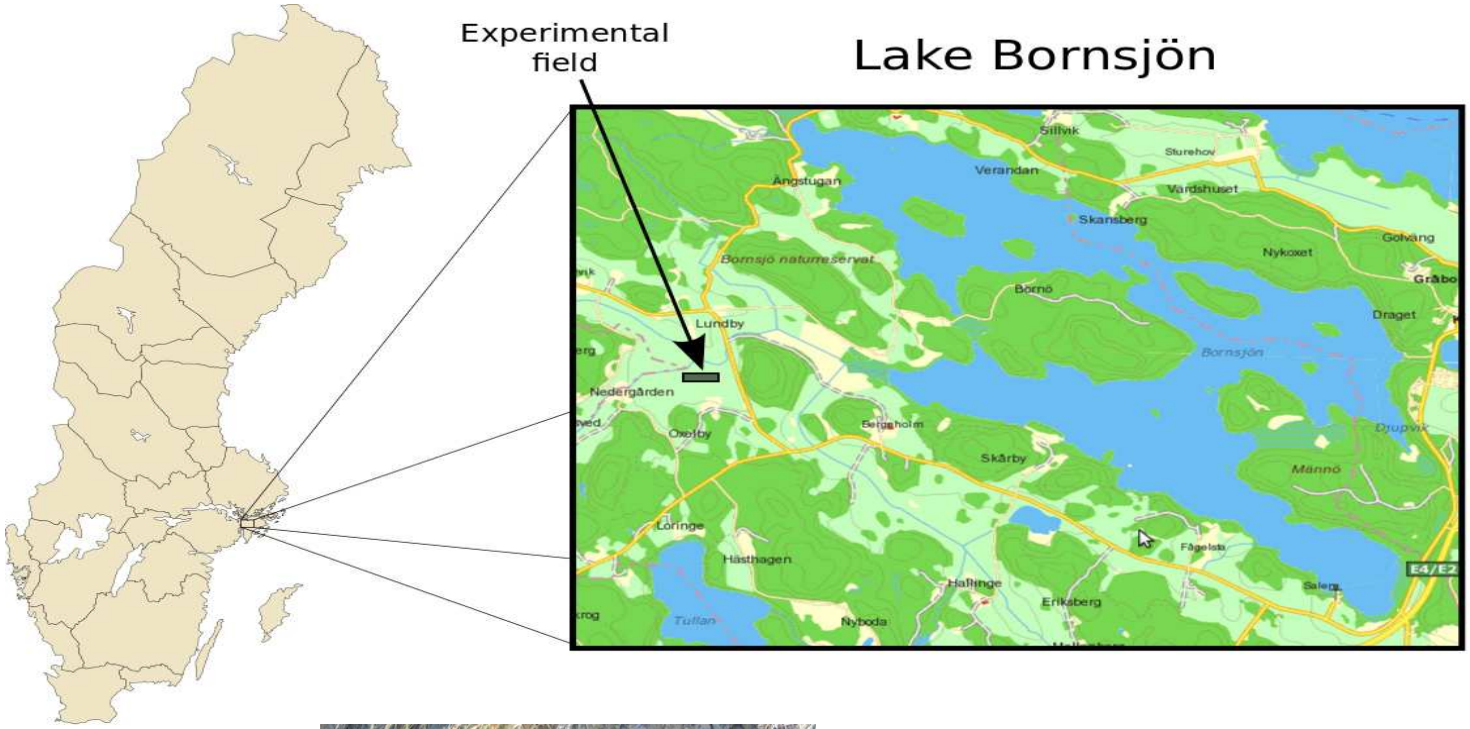
**Increased need for chemical control of weeds**
Thistle, (*Cirsium vulgare* L.) is a hard problem

**Increased need for chemical control of plant diseases harboured by crop residues on the soil surface**.

Wheat suffering from Yellow Leaf Spot (*Drechslera tritici-repentis)*

Wheat blossom midge (*Contarinia tritici*) is favored by reduced tillage

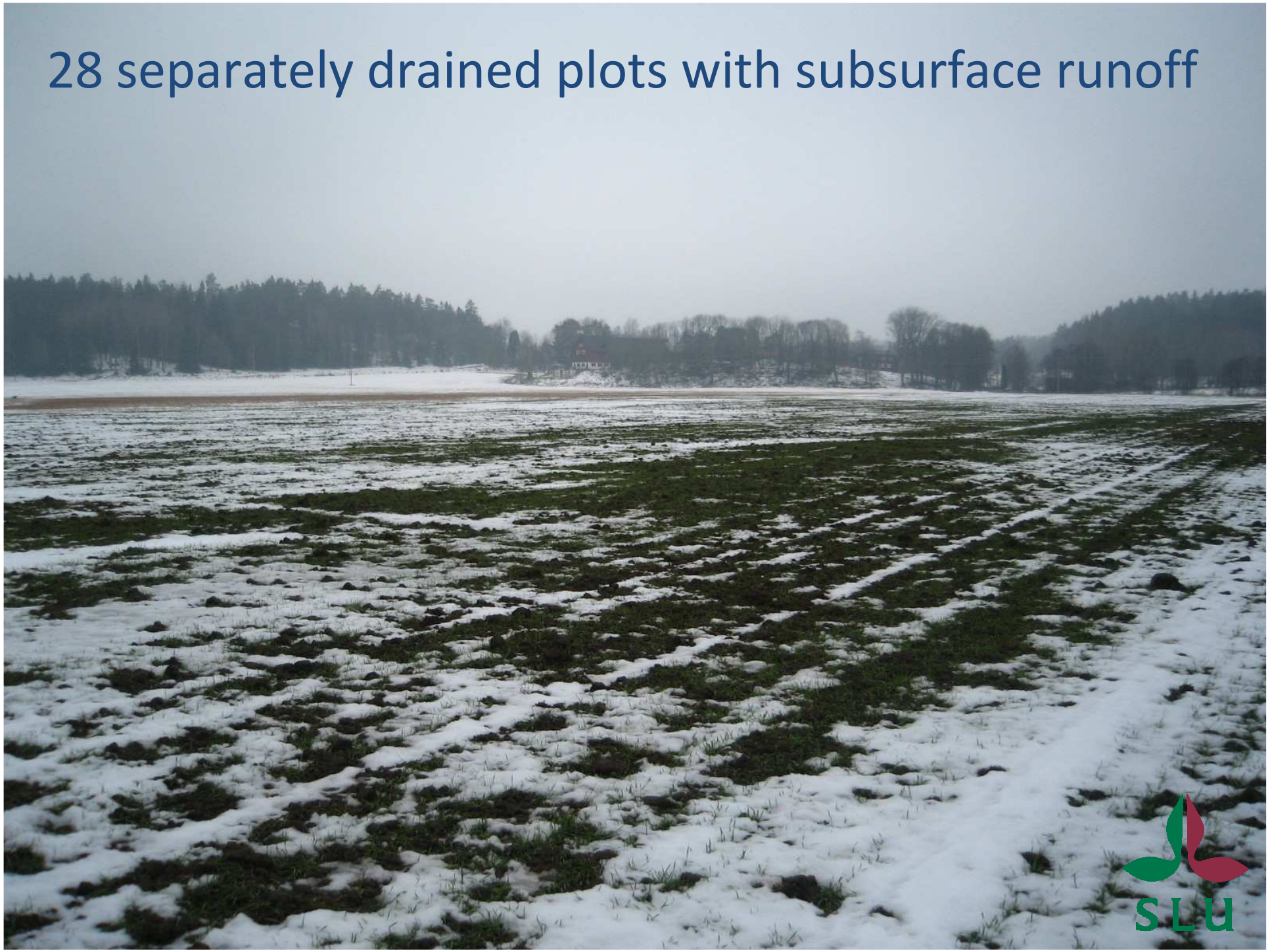
# Experimental field at Lake Bornsjön




**Marine clay soils have cracks**

Plot experiment funded by  Stockholm Water Co, Swedish Rural and Agricultural Society (Hushållningssällskap), Stockholm County Council (SLL) and Swedish Farmers' Foundation

# 28 separately drained plots with subsurface runoff

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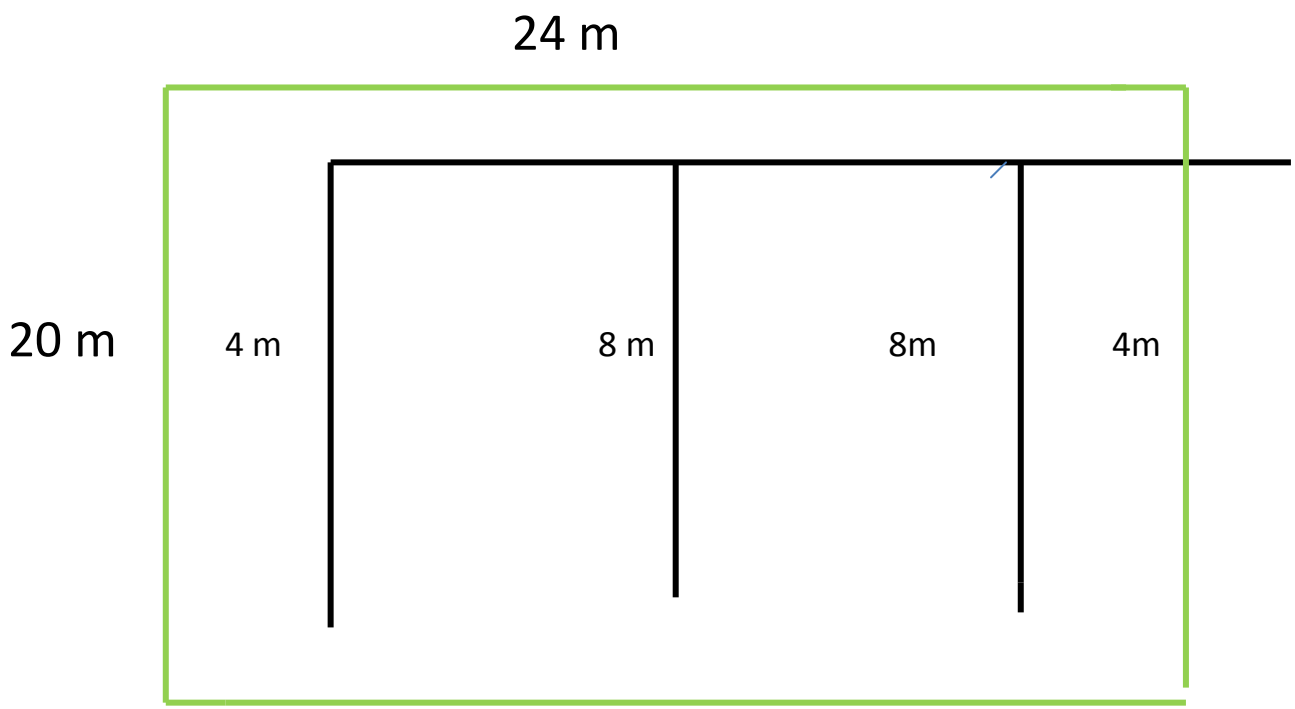
# Water-logged conditions in autumn, with high P losses

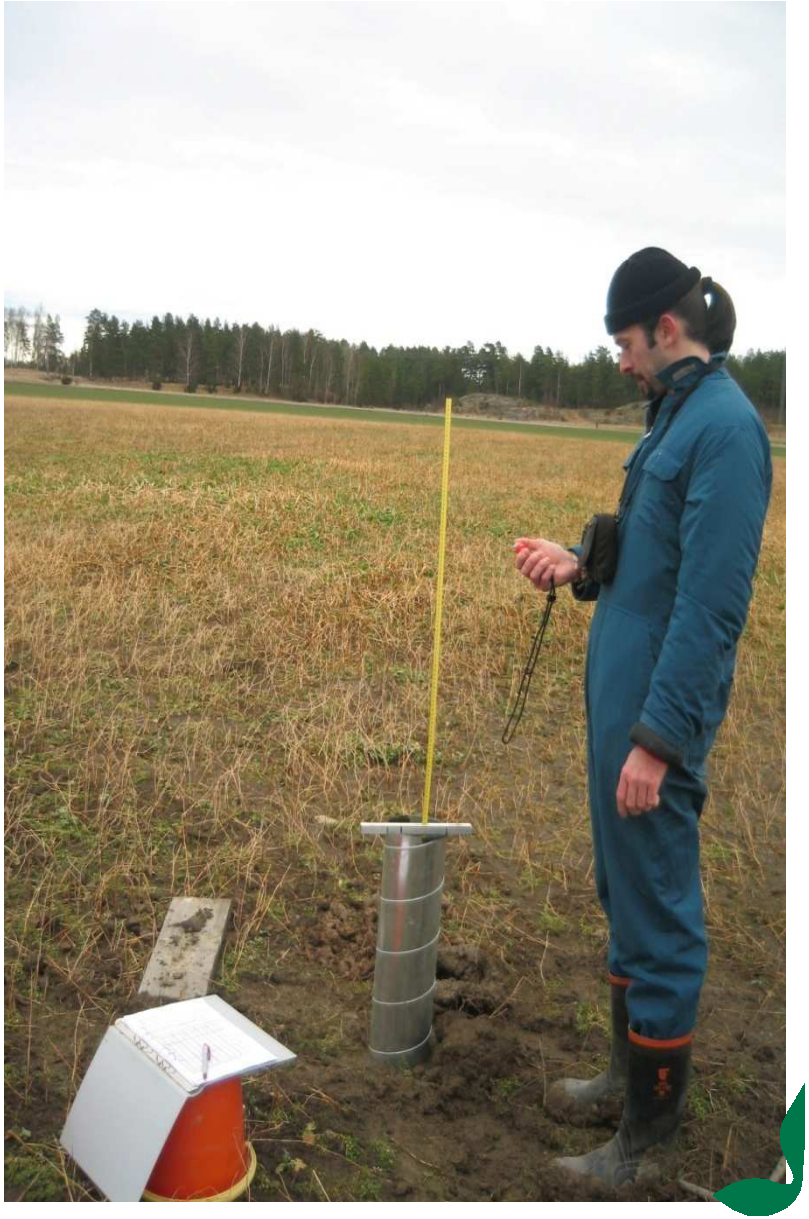
# Experimental plot



# Tilting vessels

# Sub-surface runoff water is sampled flow-proportionally

Plots are equipped with permanent pipes for measuring saturated hydraulic conductivity (K) in the soil profile



# Structure liming 5 ton/ha CaO Sept 2007


# Modern cultivator

Mean two years
(2007/2008, 2008/2009).

| **Leaching relative to harvested yield** | **TotP (kg ton$^{-1}$ *year $^{-1}$)** |
|---|---|
| | |
| Shallow cultivation | 0.22* |
| Conventional ploughing no P fertilisation | 0.17 |
| Conventional ploughing P fertilisation | 0.16 |
| Winter wheat (not barley) | 0.15 |
| Structure liming | 0.085** |

* Nitrogen leaching significant lower in second year (-36%)
** Significant lower ($p<0.05$)

No less leaching from unfertilized fallow to date

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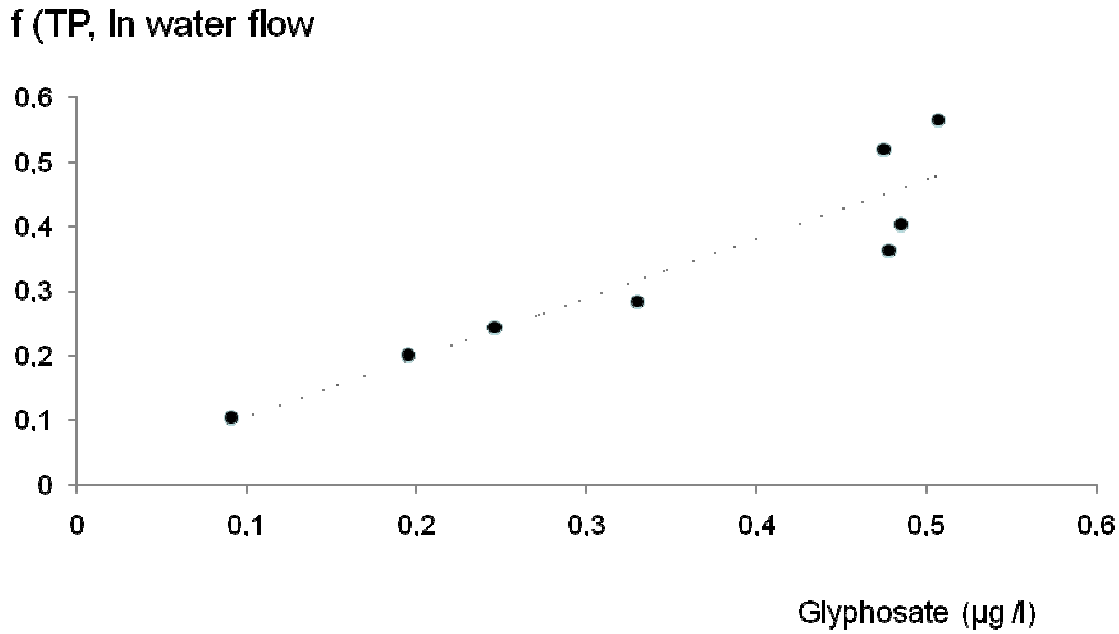
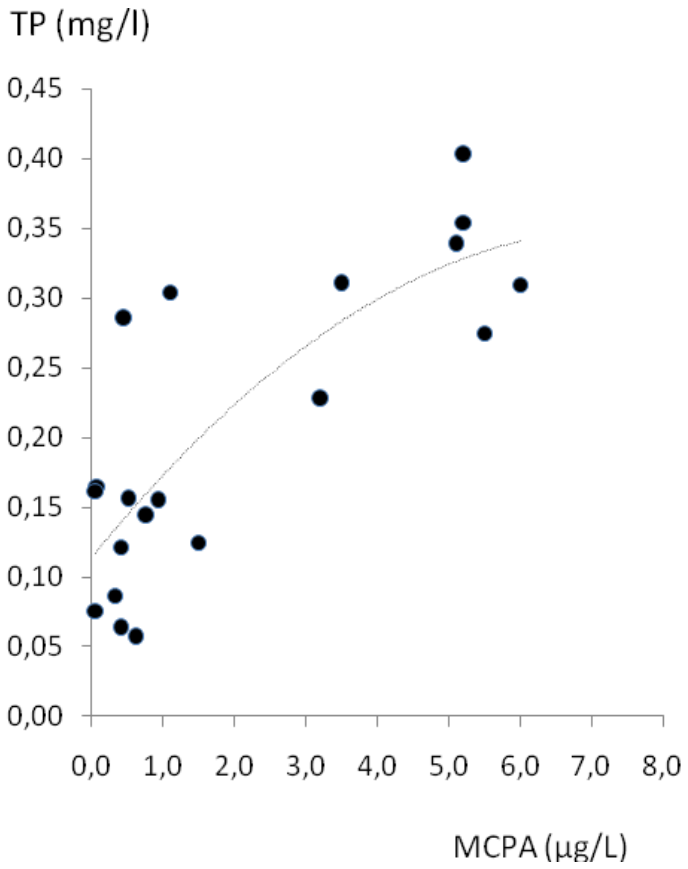
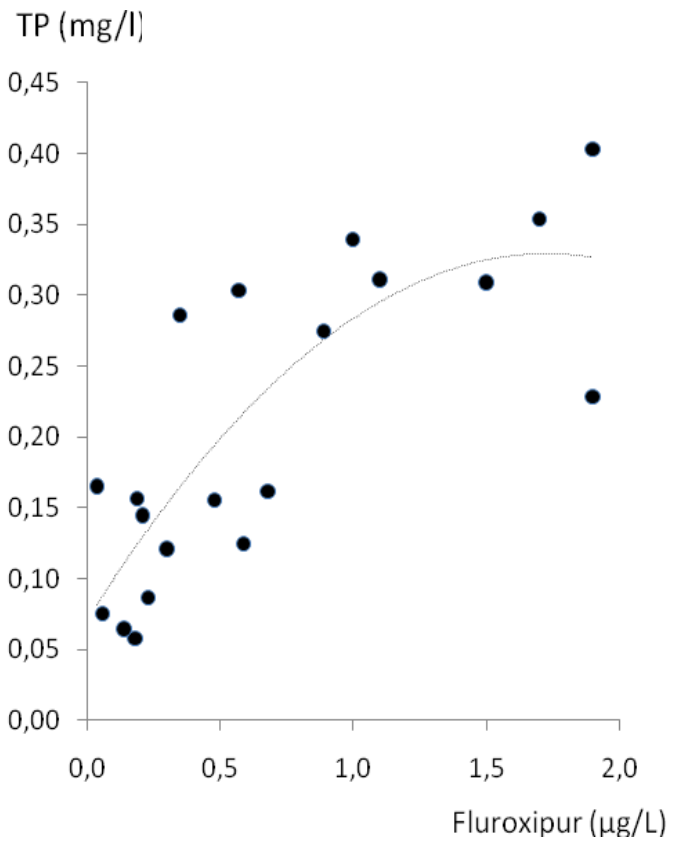
Observed concentrations of glyphosate in winter were related to measured concentrations of total phosphorus (TP) in water and logarithmic value of water flow






Plots with high phosphorus concentrations in winter generally had high herbicide concentrations in June (treatment of thistle with Ariane)

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# Leaching compared with amount applied

| Substance | Dos (g/ha) | Leaching (g/ha) ± SD | Leaching/Applied (%) |
|---|---|---|---|
| MCPA | 520 | 2.69 ± 2.41 | 0.52 |
| Fluroxipur | 104 | 0.49 ± 0.28 | 0.47 |
| Clopyralid | 52 | 1.67 ± 1.02 | 3.2 |
| Glyphosate + AMPA | 1080 | 0.76 ± 0.62 | 0.07 |
| Phosphorus fertilisation | 20 000 | | 3-5 |

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