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Nutrient load from two drainage systems

– a field scale research project on clay soil

Introduction

In Finland, subsurface drainage is a common practice in field cultivation. On average, almost 60% of the total agricultural field area (2,2 millions ha) has subsurface drainage. The proportion is 75% in southern and south-western Finland where the main crop cultivation areas are located. The state subsidizes subsurface drainage on certain conditions concerning for example different envelope materials, drain depth and total drain length per hectare. The typical drain depth is 1,0–1,2 m and the drain spacing varies mostly between 12 and 26 meters depending on the soil type. Gravel is the most common envelope, but also synthetic and semisynthetic textile, cocos fibre and wood chips are used.

In some areas gravel is not readily available and it is nowadays also rather expensive. Therefore there is a need for research on other filter materials. The objective of this study is to compare two drainage methods with different filter materials. The feasibility of the methods is evaluated from the point of view of crop production and nutrient loading to surface waters.

Field site and measurements

The research is carried out on a field at Jokioinen in south-western Finland. The soil is heavy clay and the mean slope is 1%. The size of the field is 9 ha and it consists of 4 plots each with a separate drainage system. The existing tile drainage pipes were laid in 1954 using 16 m (plots A, B and C) or 32 m (plot D) spacing and average depth of 1 m. Two different types of new additional drainage systems were built in the field in June 2008. In the method I (plot C) gravel is used as an envelope and the drain spacing is 8 m. In the method II (plot A) a very thin textile (<1 mm) is used as an envelope and the drain spacing is 6 m. The two untreated drainage systems (plots B and D) are used for comparison. During the study, small grain crops were cultivated in the field.

The subsurface drainage flow and surface runoff from each plot are measured with current-meters. The flow-weighted water samples are collected through an electromagnet valve to plastic containers. Total phosphorus (TP), dissolved orthophosphate (PO_4-P), total nitrogen (TN), ammonium nitrogen (NH_4-N), nitrate nitrogen (NO_3-N) and solid substances (SS; evaporation residue) are determined from the samples. Crop yield and quality parameters are also measured from each plot. The site was monitored for one year before the additional drainage measures to detect natural variation between the plots (calibration/reference period).

Method I

The new pipes were laid between the old ones and connected to the existing collector.

In method I the additional drainage was done with a drainage trencher, plastic pipe and gravel was used as envelope material.

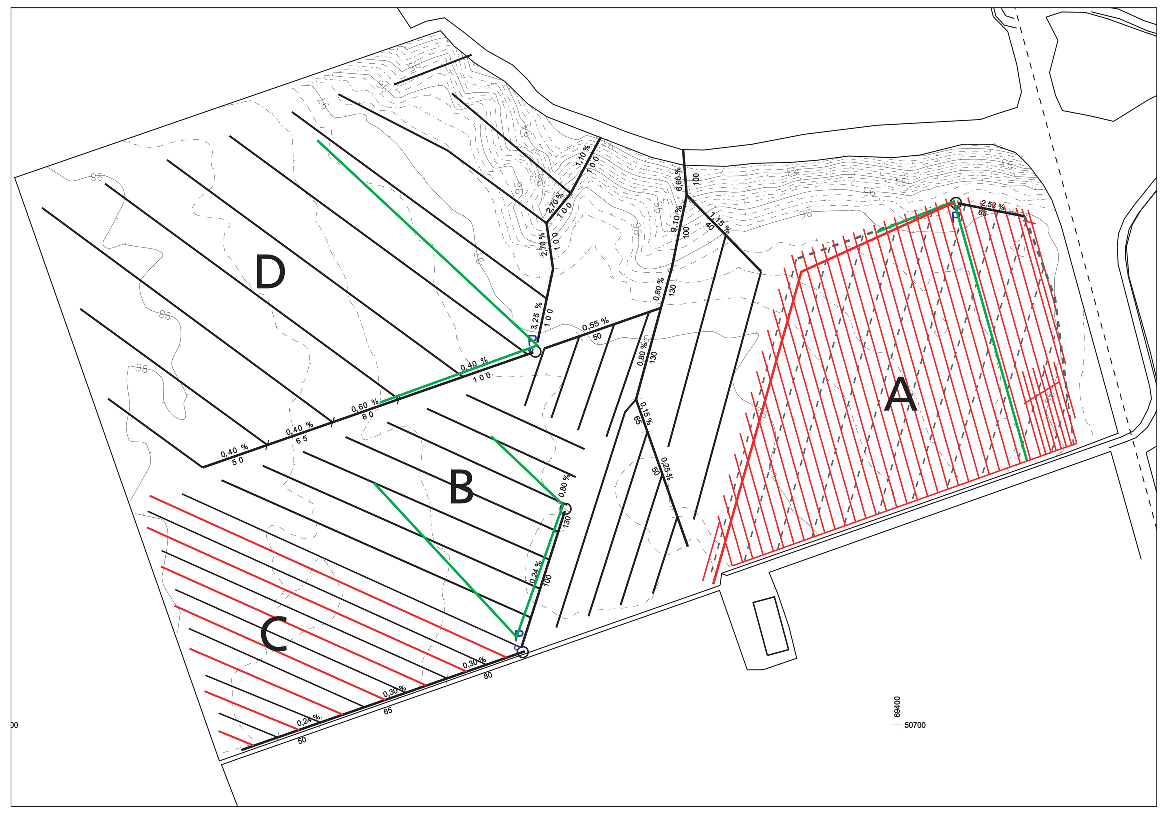
Gravel was filled to the top (blind inlet) every 8 meters. The trenched soil was left to dry for a week after which it was used to fill up the trench.

Method II

In method II a very thin textile (<1 mm) was used as an envelope. Drain spacing was 6 m. The old pipes were destroyed.

The drainage plow is equipped with a device that installs the envelope around the pipe on site before laying the pipe.

Drainage plow was used in this method. The trench closes right after the pipe laying.



The additional drainage was done on plot C with method I and on plot A with method II. Plots B and D were left as a control plots.

The subsurface and surface runoff waters from each plot are measured. The flow-weighted water samples are collected through an electromagnet valve to plastic containers for further sampling and chemical analyses.

Embankments are used to help collect surface runoff.

Results

In the figures and tables are presented the annual subsurface drainage flow, surface runoff, nutrient and suspended sediment loads and average concentrations from the calibration period, June 2007–May 2008, and the first year after the drainage improvements (research period), June 2008–May 2009. Major part of runoff and nutrient transport occurred via tile drains in all the plots due to the flat topography. However, surface runoff from the plots remained partly unclear, especially in spring 2009, due to malfunction of the measurement system.

During the calibration period, a high variation in subsurface drainage flow volumes was observed between the plot A and the plots B and C with 16 m drain spacings. This was likely due to differences in topography, location and soil properties between the plots. TP and SS concentrations in drainage waters were relatively similar in all the plots. TN concentration in the subsurface drainage flow was clearly higher in the plot A than in the other plots.

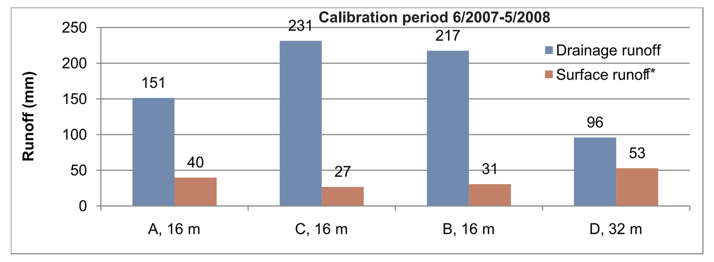
In the research period after the additional drainage measures, subsurface drain flow clearly increased in the plot C with gravel filter and 8 m drain spacing compared to the other plots. Drain flow seemed to increase in the plot A, too.

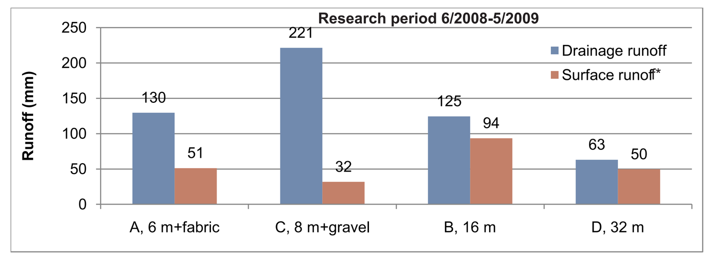
During the first year after the additional drainage, a high increase of TN concentrations and load in subsurface drainage waters from the plot A was observed compared to the other plots. In contrary, the average TP concentration and annual load were lower from the plot A than the other plots. Increase of TN concentration and load was also observed in the plot C compared to the untreated plots B and D. The average TP concentrations in the tile drain waters from the plot C remained quite similar during the calibration and research periods.

Crop yield and quality parameters showed only slight differences between the plots A, B and C in the research period. In the plot D with 32 m drain spacing, the yield was 8-12% lower than the average yield of the other plots.

At present, final conclusions about the function of the additional drainage systems can not be conducted due to the short time period after the additional drainage. The measurements will continue for several years.

Runoff

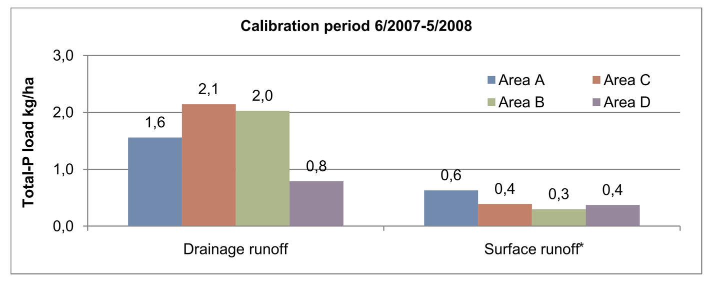


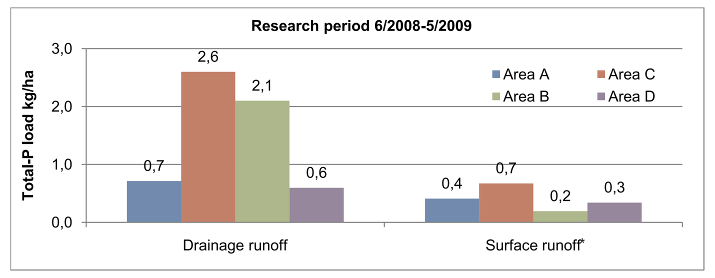


Yield

Research area (drain spacing)	Dry matter yield, kg/ha 2008	2009
A (6 m)	4389	4405
B (8 m)	4643	4865
C (16 m)	4406	4610
D (32 m)	4106	4090

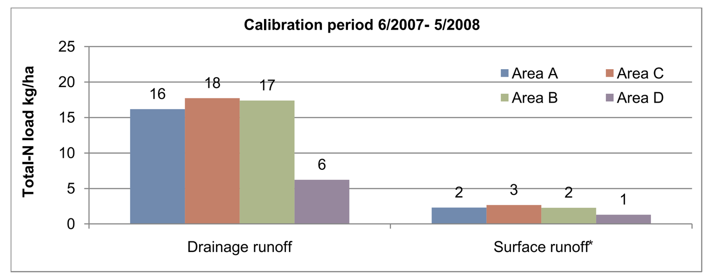
Phosphorus

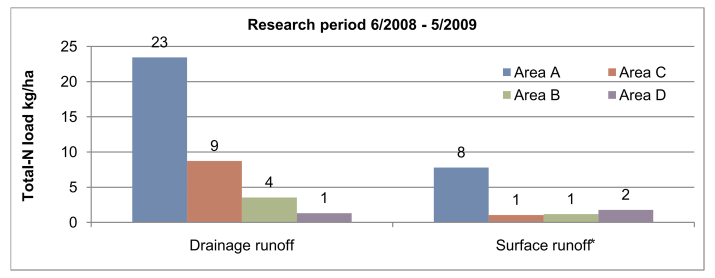




Research area (drain spacing)	Calibration period Total P, mg/l	Research period Total P, mg/l
Drainage runoff		
A (16/6 m)	0,96	0,57
C (16/ 8 m)	0,94	0,99
B (16 m)	0,76	1,41
D (32 m)	0,82	0,83
Surface runoff		
A (16/6 m)	1,42	0,76
C (16/ 8 m)	1,38	1,87
B (16 m)	0,86	0,38
D (32 m)	0,52	0,69

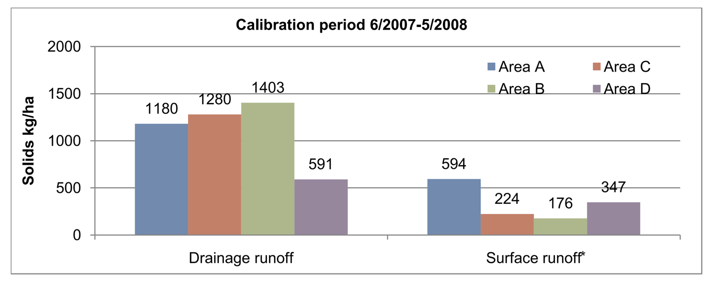
Nitrogen

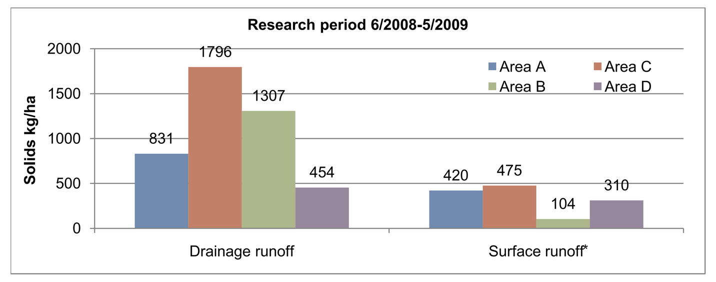




Research area (drain spacing)	Calibration period Total N, mg/l	Research period Total N, mg/l
Drainage runoff		
A (16/6 m)	12,1	17,7
C (16/ 8 m)	7,4	5,8
B (16 m)	7,1	1,8
D (32 m)	6,9	3,3
Surface runoff		
A (16/6 m)	10,4	15,8
C (16/ 8 m)	11,0	3,6
B (16 m)	8,6	1,8
D (32 m)	4,9	3,3

Suspended solid matter





Research area (drain spacing)	Calibration period Solids, mg/l	Research period Solids, mg/l
Drainage runoff		
A (16/6 m)	668	700
C (16/ 8 m)	562	720
B (16 m)	558	948
D (32 m)	570	643
Surface runoff		
A (16/6 m)	1179	784
C (16/ 8 m)	958	1360
B (16 m)	619	210
D (32 m)	553	690

*) Part of surface runoff measurements is missing