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An ASABE Meeting Presentation

DOI: 10.13031/ids.20/2521439

Paper Number:

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Subsurface drain installation methods – assessing their functionality with water table and drain outflow measurements

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Written for presentation at the

2016 ASABE 10th International Drainage Symposium

Sponsored by ASABE

Minneapolis, Minnesota

September 6-9, 2016[Click here to mention other presentations of this paper (optional)]

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ABSTRACT. *The aim of this study is to figure out the functionality of drains installed with trenchless – and trenching drainage machines and to give guidelines in the use of drainage machines in different conditions. Performance of installation methods were investigated in a field experiment. Soil type in the drainage depth varies between loam, sandy loam and clay loam. The field is flat (slope 0.16 %). Groundwater levels were measured automatically and manually from observation pipes installed at distances of 0.2, 0.6, 2.5 and 7.5 meters of the middle drain in each section. Drain outflow was measured from two collector pipes installed with each machine.*

According to results the trenchless method had slightly higher water tables in all distances of the drain by average. Differences in the water table were higher in wet seasons, when snow melting and high precipitation occurred. Trenchless machine had higher variation in groundwater levels. Drain outflow was 10% higher with the trenching method. The outflow was significantly higher in rainy seasons for short periods of time, when groundwater was up. Short research period showed that trenching method was slightly more effective. Research will continue until the end of year 2016.

Keywords. *Groundwater level, subsurface drains, trenching drainage technique, trenchless drainage technique, drain outflow.*

Introduction

Effective subsurface drainage is an essential part of crop cultivation in Finnish boreal conditions, where uneven precipitation, frost, fine textured and peat soils, relatively flat topography and a short growing season limit possibilities and practices farming.

Subsurface drains can be installed using two main techniques: trenchless and trenching machines. In the trench method, soil is excavated with a chain or a wheel trencher, and the trench needs backfilling afterwards. In the trenchless method, pipe is installed inside a tunnel made by plough and no backfilling is needed. Benefit of the trenchless machine is less work and lower costs.

Knowledge on the functionality of subsurface drainage done by the different machine types is needed to ensure their feasibility. In this study, the both installation methods have been used for drainage of a field site with open ditches.. The main objective is to examine effects of the different drainage techniques on groundwater level and drain outflow.

Experimental site and measurements

The study site is located in Sievi, in northwest Finland. Soil type of the field at the drain depth (1.0 m) varies between loam, sandy loam and clay loam. The area of the experimental site is 3.55 ha. The field is flat with a mean slope of 0.16%. The site consists of eight field sections. Each section is drained with three drains (length of 61-65 m), which are installed approximately at the depth of 1.0 m, and the drain spacing is 15 m. Four sections are drained with the trenchless machine and other four with the trenching machine. The field sections of each drainage method have a joint collector pipe. The experimental setup is presented in Fig. 1.

Drain discharge, groundwater level and precipitation have been intensively monitored in the field sections. The measurements started in June 2015. Groundwater level has been measured automatically (at 10 min intervals) and manually (two times a week) from observation pipes installed at distances of 0.2, 0.6, 2.5 and 7.5 meters from the middle drain in each section. Total amount of the observation pipes is 100. Both methods have one automatic ground water measurement station. Drain outflow from the collector pipes has been measured automatically at 10-min intervals.

Groundwater level was monitored before the installation of the subsurface drains for two months from 22 observation pipes. Particle size distribution and soil type were determined from soil samples taken in conjunction with installation of the observation pipes.

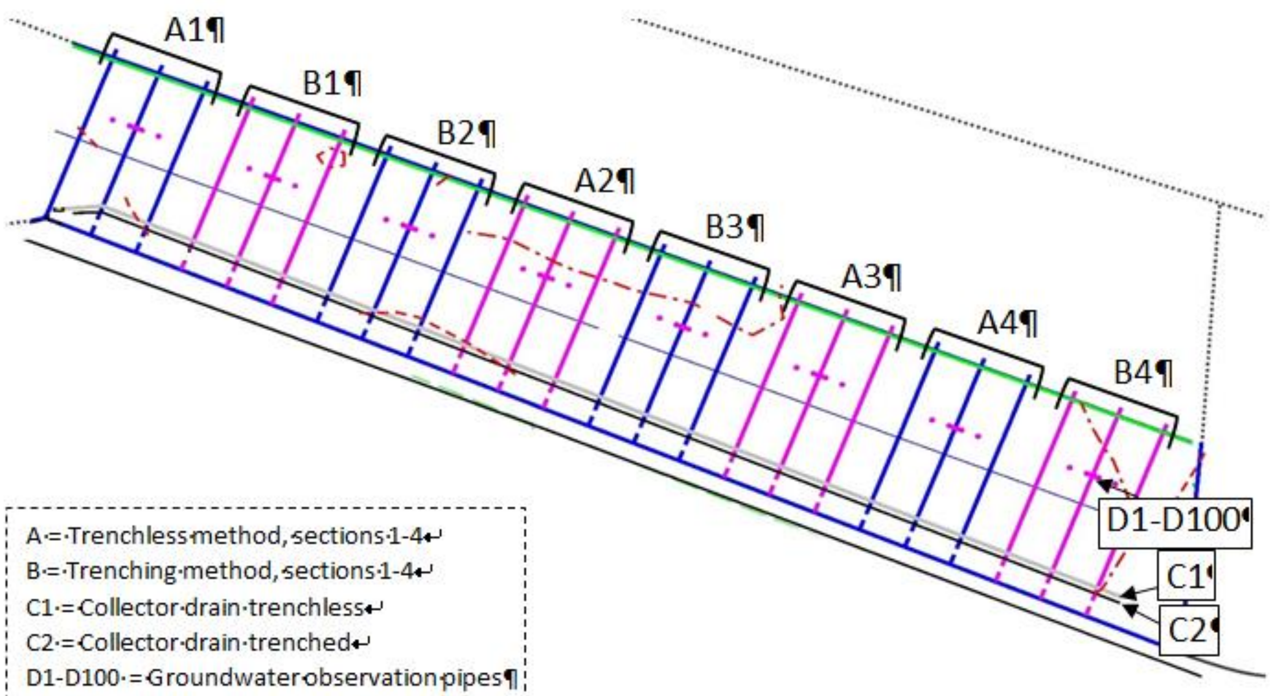


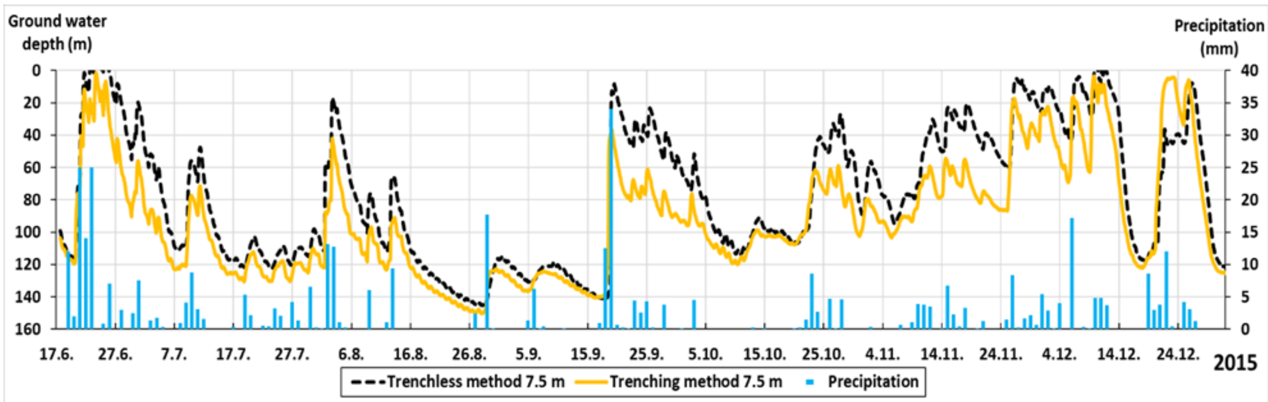
Figure 1. Layout of the experimental site and field sections with trenchless and trenching subsurface drain installation.

Results

Groundwater levels

According to the preliminary results, there has been clear variation in groundwater levels at different distances from the drain in both methods (Figure 2 and 3). In wet seasons, groundwater was higher at 7.5 m distance of the drain (midway of the drain spacing) compared to the closer distances (0.2, 0.6, 2.5 m) of the drain. Near the drain (0.2 m), groundwater was deeper through the whole measurement period. In November – December time period, trenching methods flow meter was clogged by algae, which can be seen in the results.

a)



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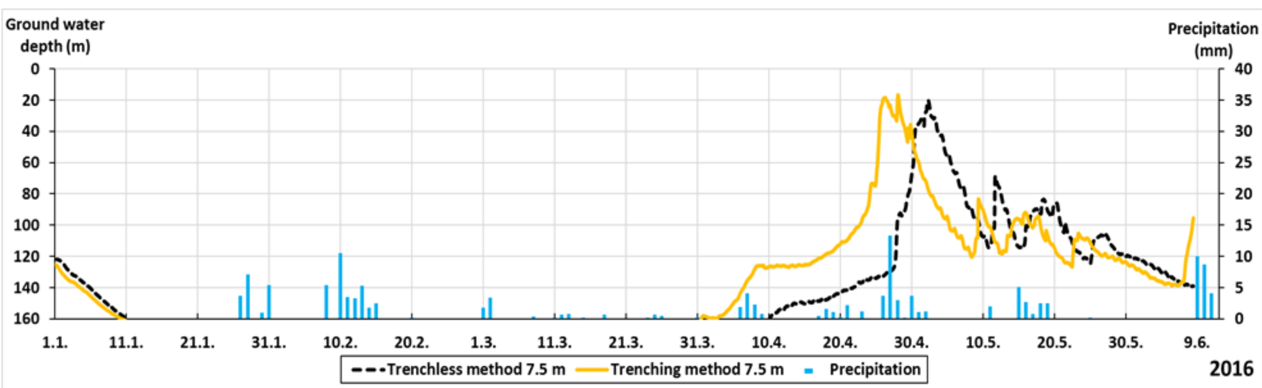

Figure 2. Groundwater table depth (cm) from the soil surface in a trenchless field section (A3) and trenching field section (B3) (at the distance of 7.5 meters from the tile drain and precipitation (mm/d) in the periods (a) 6/2015-12/2015 and (b) 1/2016-6/2016.

a)

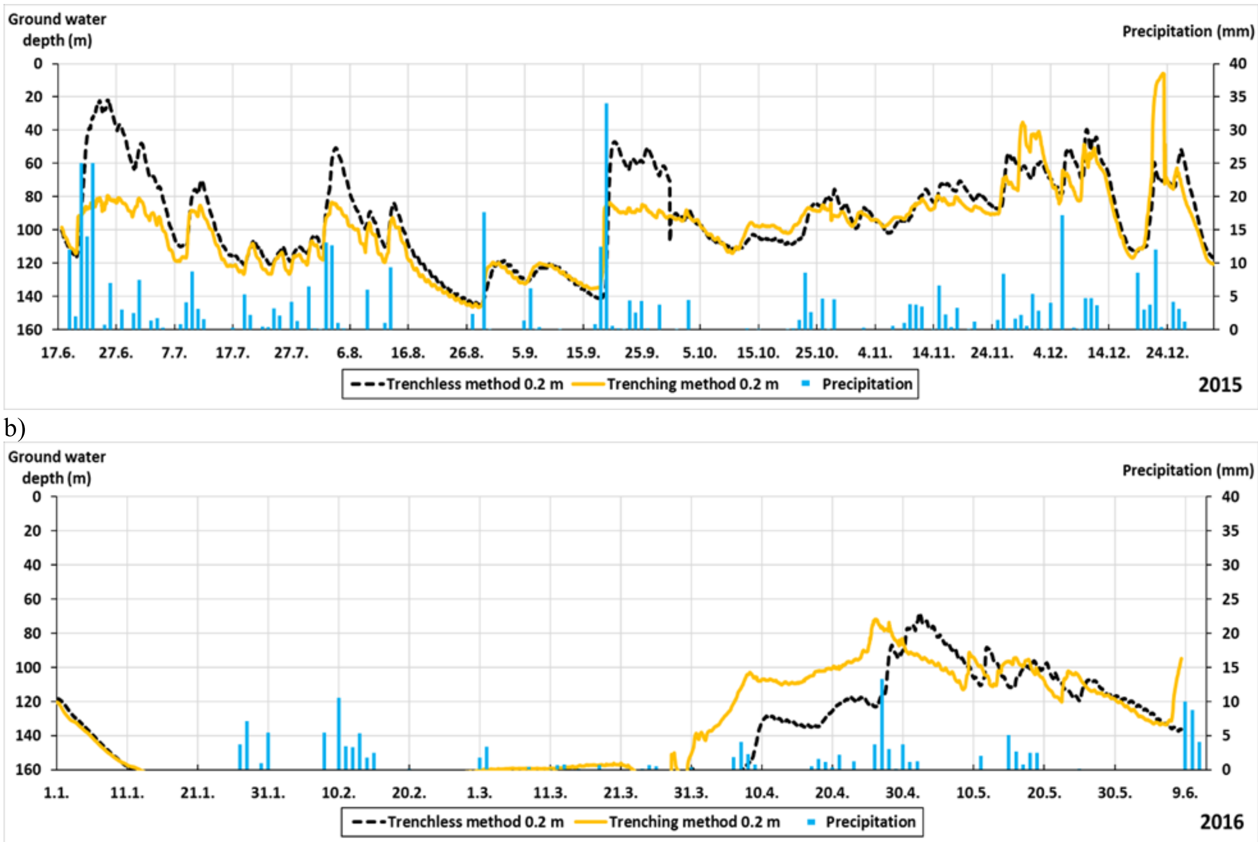

Figure 3. Groundwater table depth (cm) from the soil surface in a trenchless field section (A3)and a trenching field section at the distance of 0.2 meter from the tile drain and precipitation (mm/d) in the periods (a) 6/2015-12/2015 and (b) 1/2016-6/2016.

Figures 4 and 5 show the average groundwater table depths (manual measurements all the field sections) of both drainage methods at distances of 7.5 m and 0.2 m from the drain. Trenchless method had 1.6 cm higher water table at 7.5 m distance of the drain in the measurement period of June to December 2015. The biggest difference in groundwater levels occurred near the drain (0.2 m), where trenchless method had 6.6 cm higher water levels. At the distance of 0.6 m, groundwater level was 3.6 cm higher and at 2.5 m distance 4.5 cm higher with trenchless method. When groundwater dropped down near drain level, the differences in groundwater evened out. In dry seasons groundwater level was about the same with both methods.

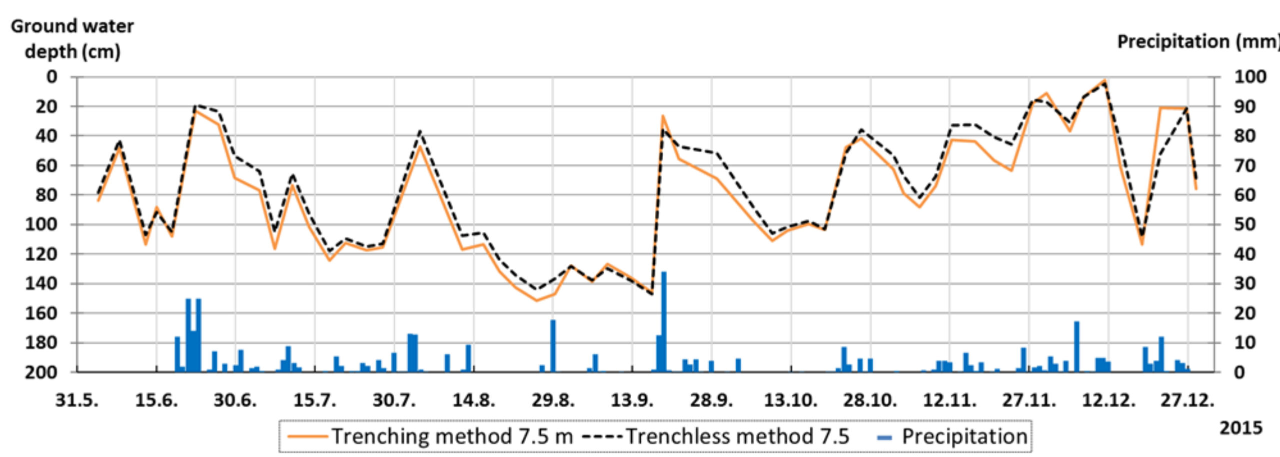

Figure 4. Groundwater table depth (average of the manual measurements; cm) at the distance of 7.5 meters from the drain and precipitation (mm/d) in the period 6/2015-12/2015. The average groundwater table depths represent the four field sections with the similar drainage method.

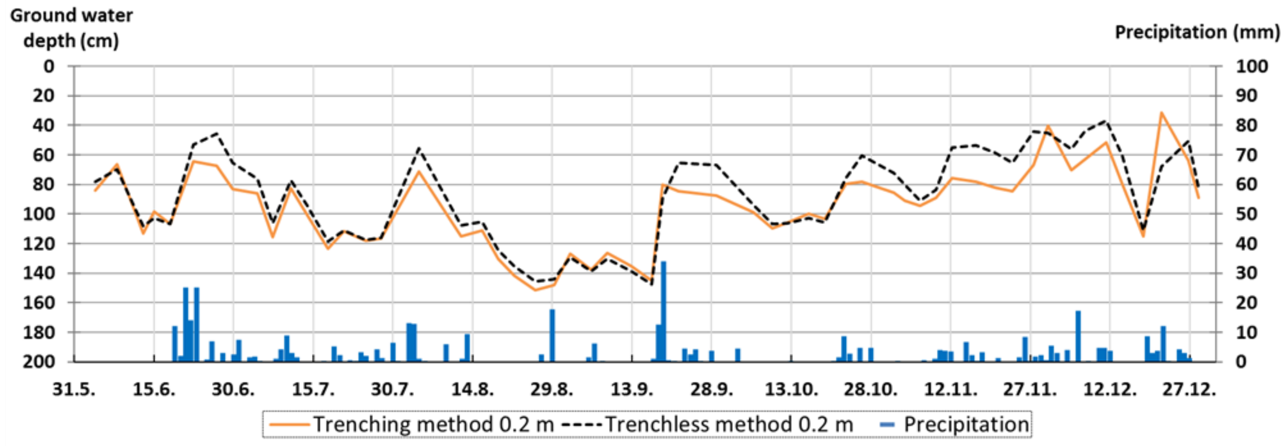

Figure 5. Groundwater table depth (average of the manual measurements; cm) at the distance of 0.2 meter from the drain and precipitation in the period 6/2015-12/2015. The average groundwater table depths represent the four field sections with the similar drainage method.

The trenchless method had a higher variation in the groundwater table depths. Variation of the groundwater table depth was higher further away from the drain with both methods. The trenching method had a low variation of groundwater table depth near the drain, and groundwater table remained at the drain depth for longer times. Groundwater table was closer to the field surface in the sections with the trenchless drainage more often than in the sections with the trenching drainage.

Drain flow

The preliminary results on drain flow of both methods are presented in Fig. 6. Drain flow occurred mostly in spring and autumn which is typical in Nordic climate conditions. In dry seasons, when groundwater was deep, no drain flow was measured in spite of relatively heavy rainfall events . On wet seasons, drain flow was higher from the sections with the trenching method. On lower flow rates due to small rainfall events , the measured drain flows were nearly the same with both methods. High rainfall events (> 30 mm/d) induced two times greater drain flow from the sections with the trenchless method than with the trenching method. These peak events were short-term, usually few hours. The total volume of the drain flow in the measurement period was 10% larger with the trenching method.

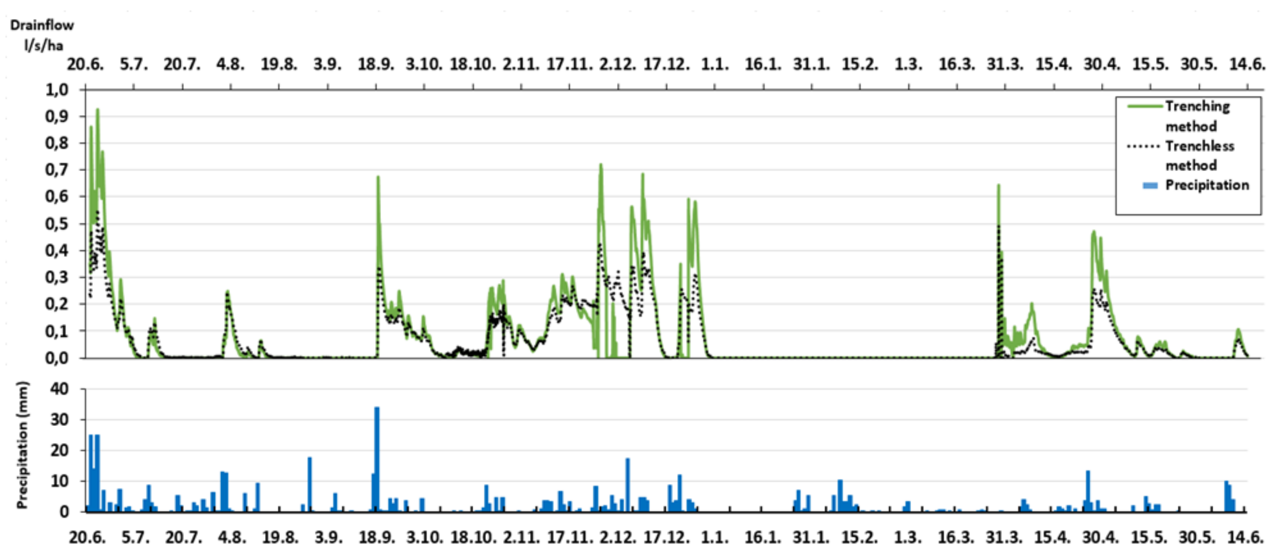

Figure 6. Drain flow (l/s/ha) from the collector pipes of the field sections with the trenchless and trenching methods and precipitation (mm/d).

Conclusions

The preliminary results show that there are no big differences in the functionality of drains installed with trenchless and trenching method in loam soils. Groundwater table depth stayed a bit lower level near the drain in the sections drained with the trenching method. Further away from the drain, midway of the drain spacing, the difference in groundwater table depth between the methods was smaller.