# A root elongation assay for assessing the impact of tillage in medium-term management trials

*T.A.Valentine[1], K.Binnie[1], R. Stobart[2], P.D. Hallett[3], N.L. Morris[4], T.S. George[1], A.C. Newton[1] and B. McKenzie[1].

**Corresponding author: Tracy.Valentine@hutton.ac.uk*
*[1]The James Hutton Institute, Invergowrie, Dundee, DD2 5DA, Scotland, UK*
*[2]Sainsbury's supermarkets Ltd,, 33 Holborn, London EC1N 2HT, UK*
*[3]Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen, AB24 3UU, Scotland, UK*
*[4]NIAB, Morley, Wymondham, Norfolk NR18 9DF, UK*

## Introduction

Tillage in various forms is a standard preparation prior to crop sowing. This process changes soil physical structure and can also alter the stratification of soil nutrients. Recent increases in the use of reduced tillage in UK exposed a knowledge gap in the effects of alternative forms of tillage on UK soils and the potential knock on effects on plant productivity and farm sustainability. The "Platforms to test and demonstrate sustainable soil management: integration of major UK field experiments" project aimed to address this knowledge gap (McKenzie et al., 2017). The project utilised four medium term (6-11 year) soil management trials within the UK including various tillage methods. The authors assessed physical, chemical (including carbon) changes, variation in cultivar yield and economic performance under the different tillage systems. The object of this part of the project was to assess changes in soil physical structure as a result of the different tillage systems and assess the potential knock on effects on root elongation and plant performance.

## Materials and Methods

Soil samples were obtained from four medium term farm management trials based in the UK (STAR, NFS and Mid-Pilmore, CSC). The sites have contrasting soil textures. Each trial included plots managed by mouldboard ploughing to 20 cm and disking (P) and at least one of the following treatments: no till (NT); shallow non-inversion tillage to a depth of 7 cm (SNI); deep non-inversion tillage to a depth of greater than 25 cm (DNI); compaction by ploughing to 20 cm followed by wheeling with an 8.8 Mg total load (C). Soil was sampled from multiple replicate plots as intact soil cores (approximately 5cm diameter x 5cm height) and as homogenised loose soil across four growing seasons. Samples were taken at the beginning and middle of the growing season, and after harvest, at a range of depths (2-7cm, 7-12cm, 25-30cm and 30-35cm). Not all combinations of depth and sampling stage were obtained, for example mid-season samples were usually only taken at 2-7cm. Intact cores were processed through a matrix potential sequence to obtain water retention curves. Soil strength measurements were taken at three matric potentials using an Instron linked needle penetrometer. Air filled porosity, volumetric water content at different matric potentials was calculated as in Valentine et al. (2012). Loose soil was sieved and packed into cores at a reduce bulk density compared with intact cores. Root elongation assays were performed at a matric potential of -20kPa as in Valentine et al. (2012) using barley (*Hordeum vulgare*) seedlings (cv. Optic) with growth recorded over 48 hours. Elongation rate was calculated by subtracting the length of the longest root at sowing from the final length. Linear mixed models were developed to assess the effects of Trial, Tillage, Sampling time and Depth on the soil physical and chemical properties and the effects of these management and soil properties on root elongation rates. All analysis was performed in R.

## Results and discussion

Significant differences in soil structure were found between the trial sites and between tillage treatments. The vast majority of the variation in soil physical and chemical properties was associated with differences between sites however there were changes in soil structure associated with the tillage methods. Significant changes due to tillage were found for dry bulk density (DBD), air filled porosity (AFV), volumetric water content (VWC) and pore space distribution in some, but not all trials. Root elongation rates in the soil cores were affected by trial site, tillage, sampling time and the depth at which the samples were taken (Figure 1). There were multiple significant interactions. Root elongation was frequently below optimum with average elongation rates ranging from 0.06 – 0.48 mm/hr. Averaged across all trials, depths and sampling times root elongation rates ranged from 0.20 mm/hr in soil from the DNI plots to 0.27 mm/hr in soil from the C plots. Thirty-seven percent of the variation in root elongation rates could be accounted for by differences in the physical status of the soil cores, accounting for a greater proportion than chemical properties (approx. 20%). In addition after reducing the differences in physical properties by repacking the soil cores at a reduced DBD no differences were found between the root elongation rates linked to Trial, Tillage, sampling time or depth. Soil pore structure and AFV were important parameters that were linked to changes in tillage, sampling time and sampling depth across the different trials, with these properties having strong correlation with the root elongation rates.

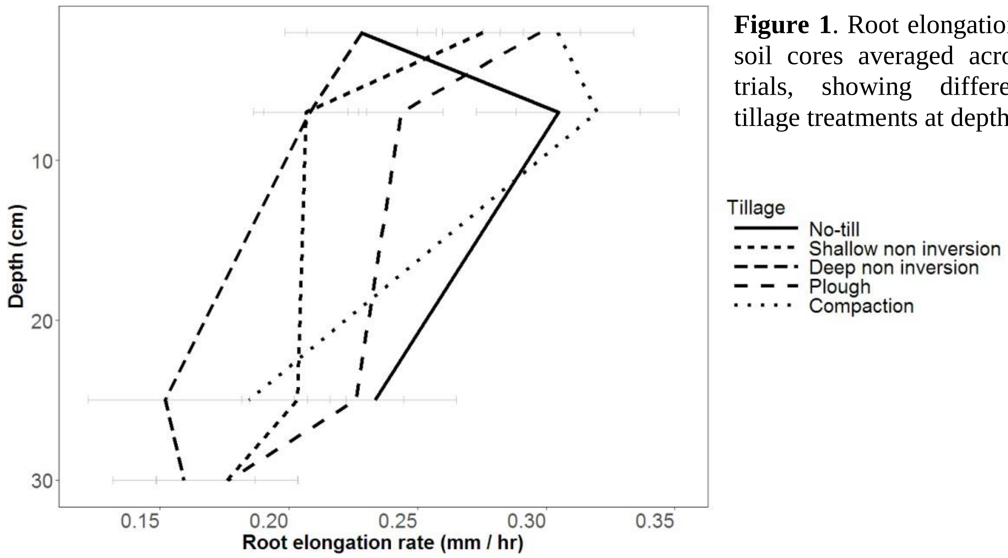


**Figure 1**. Root elongation rates in intact soil cores averaged across four tillage trials, showing differences between tillage treatments at depth.

## Conclusions

Evidence of effects of trial, tillage both within and across sites, sampling time and sampling depth were found in terms of the rates of root elongation achieved and in terms of changes in soil physical properties. Chemical properties of the soil accounted for a larger proportion of the variation in root elongation in this dataset than reported in Valentine et al (2012), however the physical properties still accounted for a greater proportion of the variation in root elongation rates than the chemical properties and the differences in the physical properties are likely to be the main drivers in differences at this early rooting stage.

## References


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