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DOES CHARCOAL (BIOCHAR) AS A CARBON SEQUESTRATION STRATEGY COMPROMISE A SOIL'S BIOPHYSICAL FUNCTIONS?

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Abstract

Charcoal was added at a rate of 2 kg/m2 (20 tonnes/ha), and mixed with the top 0.1 m of the soil. This was done at three sampling sites within a single tree row. Three separate sampling sites in the same tree row, but without the addition of charcoal served as the control. The 6 sites had the same soil type and climate, and had received the same orchard management. The charcoal was added on July 10, 2008 and samples to a depth of 0.1 m were taken on December 8, 2008.

We compared the microbial biomass, basal respiration, dehydrogenase activity, mineral-N (nitrogen) and hot-water extractable carbon (HWC) of the soil with and without charcoal as a biological and a chemical property. Using quantitative polymerase chain reaction (qPCR) we tested for the presence of microbial groups and genes associated with methane metabolism as indicators of any change in microbial diversity resulting from the addition of charcoal. As a soil physical property we analysed if the addition of charcoal increased soil water repellency.

Our preliminary analysis showed that the addition of charcoal resulted in no significant change to microbial biomass, basal respiration or HWC. The qPCR analysis showed that there was also no significant change to biodiversity. The soil in the orchard prior to the addition of charcoal was not hydrophobic; after the addition of charcoal this did not change.

Keywords: Basal respiration, microbial biomass, hot water carbon, qPCR, carbon sequestration.

Introduction

Work on terra preta de índio (TP) soil, the fertile Amazonian Dark Earths, has served as a major inspiration for the use of biochar as a promising soil additive promoting crop growth and carbon storage (Glaser et al. 2002; Glaser and Woods 2004; Lehmann et al. 2006; Glaser 2007).

Biochar is a term reserved for the plant biomass derived materials contained within the black carbon. This definition includes chars and charcoal, and excludes fossil fuel products or geogenic carbon (Lehmann et al. 2006).

The sequestering of carbon through the addition of charcoal to agricultural and horticultural soils is a strategy that has recently gained interest as a way to mitigate climate change. To assess the practical feasibility of this strategy the impact of the addition of charcoal on soil biophysical properties needs to be understood. As yet, only limited field trials have been conducted to investigate this. The objective of this study is to measure the effects of the addition of charcoal to soil in an integrated research apple orchard in Havelock North (Figure 1a), on a number of biophysical soil properties. The apple trees in the integrated orchard system were 12 yr old. The apple variety was Pacific Rose, and the rootstock variety was ‘MM.106’. The tree spacing was 3.4 m within the rows and 4.5 m between the rows. A 0.5-m wide strip under the trees was kept bare by regular herbicide applications. The apple trees were drip-irrigated during the vegetative period. The irrigation, nutrient, and pest management followed the guidelines of integrated fruit production (Wiltshire, 2003).

Figure 1a Left The integrated apple orchard.
Figure 1b Right. Mixing charcoal into the soil

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Materials & Methods

Charcoal was added at a rate of 2 kg m^{-2} (20 t ha^{-1}), and mixed with the top 0.1 m of the soil (Figure 1b). This served as the soil-plus-charcoal treatment. The charcoal was added to three sampling sites within a single tree row. Three separate sampling sites in the same tree row, but without the addition of charcoal served as the control. The 6 sites had the same soil type and climate, and had received the same orchard management. The charcoal was added on July 10, 2008 and samples to a depth of 0.1 m were taken 5 months later on December 8, 2008 (Figure 1c).

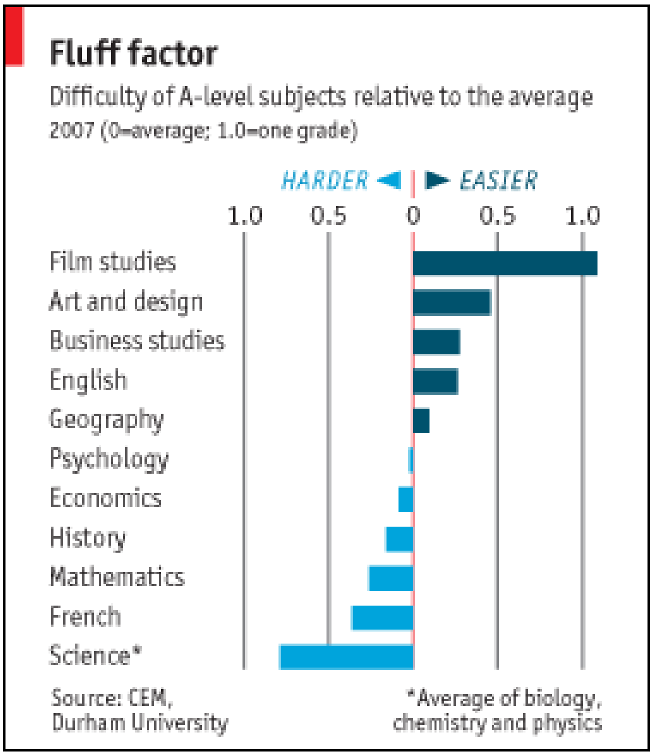
Figure 1c. Collecting soil samples

We compared the microbial biomass according to the method of Höper (2006). Microbial respiration was determined by using basal respiration (Őhlinger et al., 1996), Dehydrogenase activity (Chandler and Brooks, 1991) and microbial biodiversity of the soil with and without charcoal as biological soil properties.

Detecting microorganisms by polymerase chain reaction (PCR) amplification of Deoxyribonucleic acid (DNA) extracted from environmental samples has an advantage over culture techniques which requires recovery and growth of active organisms (Johnston and Aust, 1994; Sivakumaran et al., 1997). DNA was purified from three samples of each soil type using PowerSoil DNA kit (MoBio Laboratories, Carlsbad, Ca, USA) following the maker's instructions. Microbial biodiversity was analysed using quantitative polymerase chain reaction (qPCR). Sixteen microlitre qPCR reactions were performed in triplicate on two separate plates on a LightCycler 480 (Roche Applied Science, Indianapolis, IN, USA) using 25 ng of DNA, 0.5 µM primers with LightCycler® 480 SYBR Green I Master (Roche Applied Science, Indianapolis, IN, USA). Cycling conditions included an initial hot start at 95 °C for 5 min, followed by 40 cycles of 95 °C for 10 s, 53 °C for 10 s and 72 °C for 30 s. Each qRT–PCR was ended by the addition of a dissociation curve analysis of the amplified product. This involved denaturation at 95 °C for 5 s, cooling to 65 °C for 1 minute and then gradual heating at 0.21 °C/s to a final temperature of 97 °C. Raw crossing points were converted to quantities representing relative expression levels using a modified comparative method (Pfaffl, 2001) and with correction for different amplification efficiencies (Ramakers et al., 2003). Primers used in qPCR of 16S rRNA in Eubacteria, and sulfate-reducing bacterial groups Desulfovibrionaceae, Desulfobacteraceae and Desulfobulbus were 9/27f, 519f, 519r, 907r, DSVIB679r, DSBA355f and DSBb279f from Stubner (2004); primers for urease gene wereURE1F and URE2R from
Continued on page 3

The Aspiring Student

This **WISPAS** we honour as our *Professionals* – the aspiring students – especially those who do the hard yards (see below)



Strategic Thinking for the Aspiring Student

From *The Economist*, December 18, 2008 … For the 300,000 or so British youngsters putting the finishing touches to university-application forms over the Christmas holidays, it is decision time. Which institutions to choose? Which of the myriad alluringly (and sometimes improbably) titled degree courses? Weighty decisions, no doubt, but evidence is mounting that the more crucial choices were made two years earlier, when students picked which three or four subjects they would continue to study until leaving school.

Many may have chosen the wrong ones, and damaged their chances of getting into a highly regarded university. Policy Exchange, a centre-right think-tank, looked at the A-levels offered by successful applicants to a group of 27 very selective universities — some ancient, some modern — and concluded that, despite the fact that all subjects are notionally equal, in reality admissions tutors think more of some than of others.

A tenth of all A-levels are in art and design, or drama, film and media studies—but only a twentieth of those taken by students who gained places at top universities. Researchers at Durham University compared the relative difficulty of every subject, and found that no matter which method they used, some subjects really did turn out to be harder than others—so much so that a candidate could expect a result two grades higher in the easiest subject than in the hardest (see chart above). The widespread perception that sciences are particularly difficult turned out to be correct—and the order in which subjects were ranked matched closely the perceived preferences of selective universities.

Students are misled into choosing supposedly non-existent soft subjects—and are then at a loss to understand why they missed out on coveted university places, despite their high grades.

[It would seem to pay to be a French-speaking scientist good at mathematics!]

Continued from page 2

Koper et al. (2004); primers for type I and II methanogtroph 16S rRNA were taken from Chen et al. (2007) and for methane oxidases from Holmes et al. (1995). We tested for the presence of microbial groups and genes associated with methane metabolism.

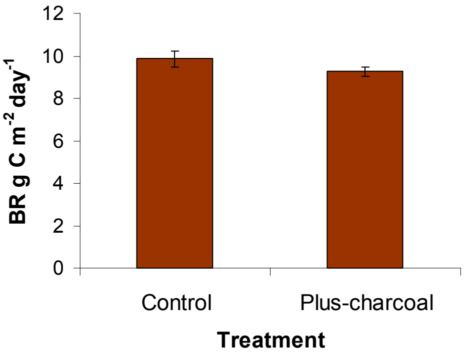
Hot water extractable carbon (HWC) (Ghani et al., 2003) and mineral-N (nitrogen) content (Keeney and Nelson, 1982) were compared as chemical soil properties.

As a soil physical property we analysed if the addition of charcoal caused the soil to become hydrophobic. (Roy and McGill, 2002).

Data were analysed using 95% confidence intervals.

Results

Biological properties
Addition of charcoal had no significant impact on basal respiration or microbial biomass (Figure 2a & b).



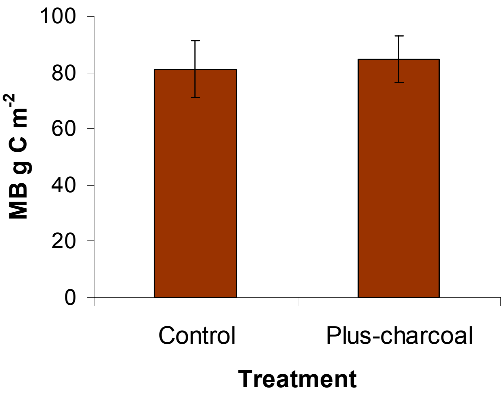
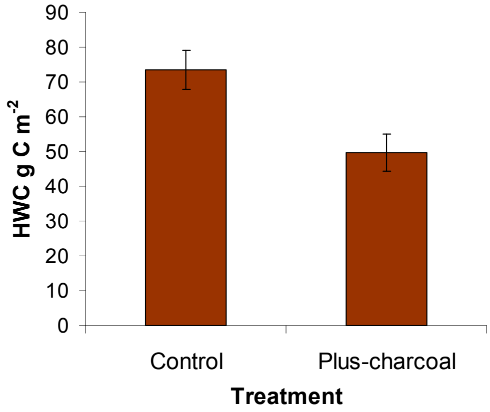


Figure 2a Left. Basal respiration measured in soil with and without the addition of charcoal. (Error bars are mean ± s.e., n = 9). Figure 2b Right. Microbial biomass measured in soil with and with out the addition of charcoal. (Error bars are mean ± s.e., n = 9).

Following experimentation we found that dehydrogenase activity cannot be reliably quantified in soil if charcoal amendments have been added, since the charcoal interferes with the absorbance readings.

There was no significant change in population size of methanogens, methanotrophs, ammonia-oxidising bacteria, eubacteria, fungi, archaea, α-proteobacteria and β-proteobacteria resulting from the addition of charcoal to the soil.

Chemical properties
The hot water extractable carbon (HWC) content was significantly lower in the soil-plus-charcoal than in the control (Figure 3a).



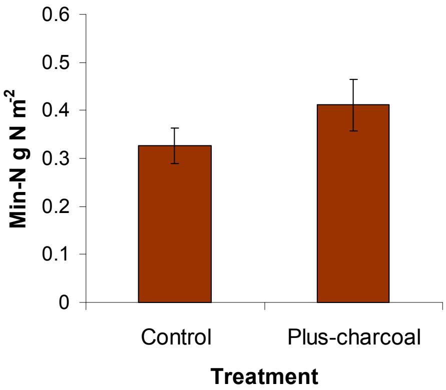


Figure 3a Left. Hot water extractable carbon (HWC) content of soil with and with out the addition of charcoal (Error bars are mean ± s.e., n = 9). Figure 3b Right. Mineral-N (nitrogen) content of soil with and without the addition of charcoal. (Error bars are mean ± s.e., n = 6).

The addition of charcoal led to no significant change in mineral-N content (Figure 3b).

Physical properties
The soil in the orchard prior to the addition of charcoal was not hydrophobic; after the addition of charcoal this did not change. When testing for hydrophobicity it was noted that pure charcoal was slightly water repellent.

Conclusions

Most of the measured properties of the orchard soil were not significantly affected by the addition of charcoal during the five months of this trial. However, the difference in HWC content could be an early indicator of changes that may become more significant over a longer period of time. Comparing the N-mineralisation rates of the two treatments would further indicate if changes are occurring. To properly assess what effect the addition of charcoal has on a soil's biophysical functions further trials and analysis are required.

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Could hydrophobicity influence soil infiltration rate - even around field capacity or wetter?

Preamble. *This PhD project seeks more realistic understanding of the actual dynamics of water flow during infiltration into field soils which are both structured (i.e. with macropores) and layered. This second article (see also WISPAS 99:5-6) investigates the role of soil hydrophobicity in controlling early-time (sorptivity stage) infiltration.*

Introduction

All 'standard' infiltration models share the feature that the infiltration rate (i_t) is higher when water first enters the soil and then decreases with time. The commonest model is the equation of Philip (1957):

$$I = S\sqrt{t} + At \qquad \textbf{Equation 1}$$

where I is cumulative infiltration, S the soil sorptivity (a function of the supply water potential Ψ_0 and the antecedent soil matric potential Ψ_i), t is time, and A is related to the soil's hydraulic conductivity. Generally it is accepted that at early times the first term of Eq. 1 is dominant, as the air-filled pore space exerts sufficient capillary forces (via the. matric potential, Ψ_m) to cause rapid imbibition of water.

In the results of our study the early-time infiltration often manifested an i_t starting slowly and then increasing with time, the reverse of the behaviour predicted by Eq. 1. This behaviour raised the possibility that other non-sorptivity mechanisms may influence early-time infiltration.

Methods

The soil type is a well-drained silt loam, classified as a Typic Firm Brown, and formed into ~1m of loess under rainfall of ~930 mm yr^{-1}. The soil had been under pasture for ~20 years, with good topsoil aggregation, and soil organic carbon of 3.5 – 4% at 0 – 5 cm depth. Infiltration experiments were conducted on four lysimeters (50 x 70 cm deep) using a 49 cm diameter tension infiltrometer that supplied infiltrating water under surface-imposed suctions of 0, 0.5, 1 and 1.5 kPa. Drainage at the lysimeter base was under the same controlled suctions.

Between experiments the infiltrometer was removed and lysimeters were allowed to drain down to achieve similar antecedent conditions, as indicated by measurements of Ψ_m (i.e. -5 to -10 kPa in the topsoil). Soil water dynamics within lysimeters were measured in-situ at depths corresponding with soil layer boundaries using tensiometers and CS616 water content reflectometers.

The degree of hydrophobicity was assessed using the intrinsic sorptivity method (ISM) of Tillman et al. (1989), which compares the sorptivity of water (S_w) relative to ethanol (S_e). (Ethanol is used as a reference liquid unaffected by hydrophobic compounds during infiltration). In a non-hydrophobic soil S_w/S_e should be 1.95, due primarily to the greater surface tension of water. The degree of hydrophobicity is indicated by the Repellency Index (RI),

$$RI = 1.95(S_e/S_w) \qquad \textbf{Eq. 2}$$

where RI > 1.0 indicates hydrophobicity. In this sense RI indicates how much hydrophobicity has lowered S_w, so that a potential S_w in non-hydrophobic conditions can be estimated as S_w multiplied by RI (Wallis et al., 1991).

The main advantage of using the ISM is that it allows the effects of hydrophobicity on infiltration to be assessed for undisturbed soils at any antecedent water content. Following the lysimeter infiltration experiments, three small cores (10 x 5 cm depth) were sampled from the surface of Lysimeter 1. Infiltration of water and ethanol were measured separately for each core under a surface suction of 0.4 kPa, with the cores equilibrated prior to each infiltration experiment at a Ψ_m of -8 kPa, i.e. the same antecedent Ψ_m measured for the equivalent L1 0.5 kPa infiltration experiment.

Lysimeter early-time infiltration results

The early-time infiltration is shown in Fig.1 using infiltration rates calculated over 1 mm cumulative infiltration intervals for the first 20 mm. An initially higher i_t is apparent for the first 3 – 4 mm of saturated infiltration for L2, L3 and L6, and also for the first 1 – 3 mm of unsaturated infiltration into L2 and L6 (e.g. L2 0.5 and 1 kPa). However, the initial sharp decline in i_t is followed by an increase. Unsaturated experiments for L1 and L3 0.5 kPa show a contrasting pattern, where i_t starts slowly and then steadily increases. In some experiments i_t fluctuates, with no clear overall pattern (e.g. L3 1.0 and 1.5 kPa). The only experiment consistent with the Philip model is L2 1.5 kPa, where i_t starts at 10 mm hr^{-1}, and then steadily declines to 0.1 – 0.2 mm hr^{-1} by I = 6 mm.

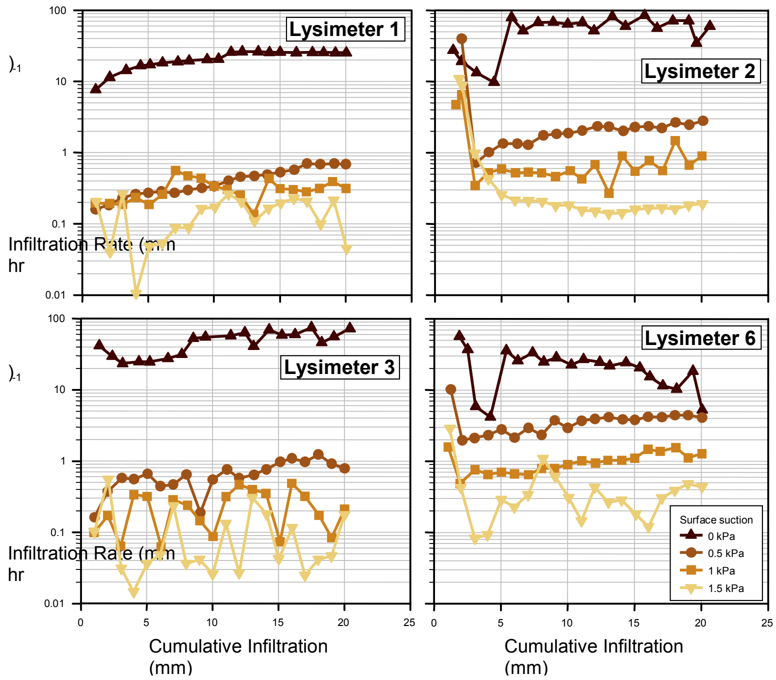

Fig. 1. Comparison of transient-phase infiltration rates of four lysimeters, under controlled surface suctions of 0, 0.5, 1 and 1.5 kPa. This phase is assumed to occur within the first 20 mm of cumulative infiltration.

Discussion

If sorptivity is not the dominant force governing early-time infiltration, then some other mechanism is slowing capillary forces from drawing the infiltrating water into the soil pores. Slow infiltration may be an artefact of the tension infiltrometer system, or otherwise is an intrinsic soil effect. Possible mechanisms include:

a) The infiltrometer-lysimeter system: poor contact with the soil surface, or an air 'back-pressure' effect caused by confinement of displaced soil air.

b) Soil mechanisms: hydrophobicity; high antecedent soil wetness; air-entrapment; or surface seal development.

In results not shown here we were able to demonstrate that most of these mechanisms were likely to have minor or no influence on the slow early-time infiltration behaviour. The exception is hydrophobicity which appears to have had a significant influence.

Hydrophobicity characterisation

Wallis (1991) showed that 14 NZ soils from three different regions, with a wide range of textures, all exhibited varying degrees of hydrophobicity at field moisture conditions. Soils which appear to wet normally may still have water repellency of hydrological importance, and even soils with weak apparent hydrophobicity were shown to potentially decrease early-time infiltration by c. one order of magnitude, under high intensity rainfall. The θ_i of soils in the study of Wallis (1991) were considerably drier than those in this study. However, strong hydrophobic influence was observed by Clothier et al. (2000) for the Ramihi soil for $\theta_i \approx 40\%$, and by Jarvis et al. (2008) for a soil with $\theta_i \approx 36\%$. This is similar to this study where θ_i was 40 – 50%.

In this study hydrophobicity was assessed retrospectively, in response to the unusual early-time infiltration behaviour consistently observed for the lysimeters. Fig. 2 shows the results, together with estimates of S_w and S_e for each core. The average S_w is estimated as 1.2 mm $hr^{-1/2}$, compared to an average S_e estimate of 5 mm $hr^{-1/2}$, providing an average RI of 8 for the three cores. This RI value clearly indicates that hydrophobicity is present under these infiltration conditions, and was likely to be an important mechanism governing the early-time infiltration into the lysimeters.

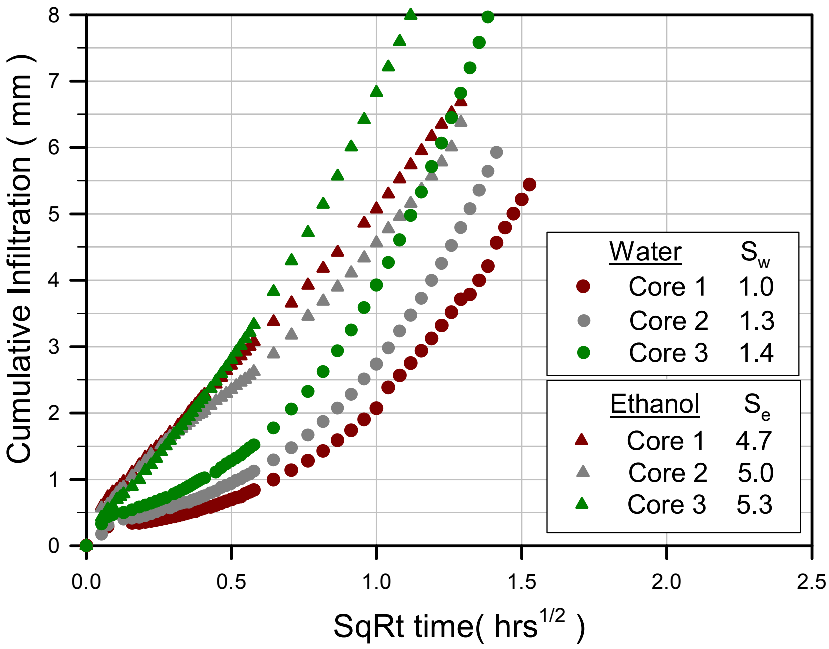

Figure 2. Comparison of the early-time infiltration of water and ethanol into three small cores from the 0 – 5 cm depth of Lysimeter 1, to estimate the sorptivities of water (S_w) and ethanol (S_e). Sorptivity is estimated from the slope of the most linear portion of early-time infiltration.

Use of the hydrophobicity knowledge

Fig. 3 shows results of three replicate saturated infiltration experiments into a large (22 x 22 cm) core sampled from the topsoil layer of Lysimeter 3. The antecedent matric potential and experimental setup were similar to the equivalent whole lysimeter experiment. Slow early-time infiltration is still evident, which should not occur if the similar lysimeter behaviour was due to subsoil-induced air confinement. Infiltration is consistently stalled for the first 4 – 5 mm, after which there is a distinctive increase in the infiltration rate. This is consistent with hydrophobicity effects observed in this study and by Clothier et al. (2000). It is also consistent with this studies lysimeter scale experiments, where early-time stalling was evident for the first 5 – 10 mm infiltration.

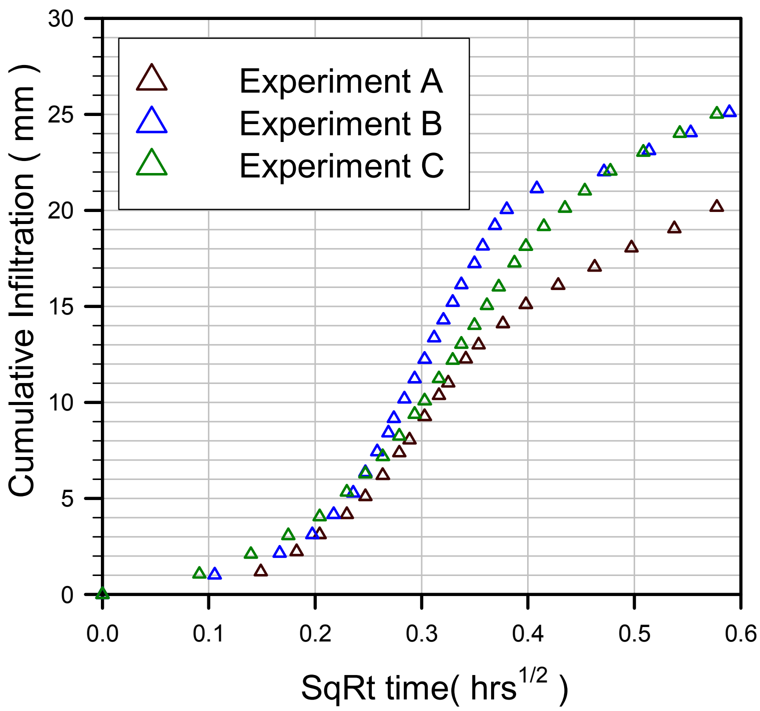

Figure 3. Replicated early-time saturated infiltration into a large (22 x 22 cm) core extracted from the topsoil layer of Lysimeter 3

The most interesting feature of Fig. 3 is that once hydrophobicity breaks down, infiltration follows the 'classic' Philip model (Eq. 1), with a faster sorptivity phase followed by the steady-state phase. The sorptivity phase was also evident at the whole-lysimeter scale, but was obscured by the confounding influence of hydrophobicity. Ignoring the hydrophobicity phase provides sorptivity values during saturated infiltration of 70 – 100 mm $hr^{-1/2}$ for the core experiments, and 70 mm $hr^{-1/2}$ for the lysimeter.

Summary

Analysis of early-time infiltration behaviour revealed an absence of clear sorptivity-driven behaviour, of the type predicted by Philip's (1957) infiltration model. This behaviour was consistent across four lysimeters, and during infiltration under different surface-imposed suctions.

The most likely mechanism governing early-time infiltration is weak hydrophobicity, which appears to restrict infiltration for the first 5 – 10 mm of infiltration.

Acknowledgements

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Scientific Truth

Every great scientific truth goes through three stages. First, people say it conflicts with the Bible. Next they say it had been discovered before. Lastly, they say they always believed it

Louis Agassiz 1807-1873
(Agassiz first proposed that the Earth had had Ice Ages)

Impact on saturated / near-saturated hydraulic conductivity of converting pasture to crop rotation and return to pasture

Preamble. This article describes a new research collaboration between Lincoln University, NZ, and the Dresden University of Technology (TUD), Germany, in which Dr. Kai Schwärzel (TUD) tested use of the new 'hood infiltrometer' to measure the near-saturated hydraulic conductivity of a soil in Canterbury.

Introduction and Objectives

Arable cropping can have large impacts on soil properties, compared to pasture or forests, due to frequent soil disturbance, compaction, greater use of agrochemicals and higher off-takes of plant biomass (Sparling et al., 2000). Hence mixed pasture-crop-pasture rotations (with both phases of 2 to 5 years duration) are common practice in New Zealand, as the pasture enables both soil structure-building and nutrient replenishment. Such management practices modify the soil's structure and pore-size distribution (PSD). In particular, the saturated and near-saturated soil hydraulic properties are very sensitive to these management-induced changes. Methods for quantifying the interactions between crop/ soil management practices, and soil structure/ PSD are needed to improve our capacity to assess the overall impacts of agricultural practices on soil 'physical fertility', and on the water balance. For two decades, disc infiltrometers have been commonly used to assess differences in soil hydraulic conductivity $K(\psi)$ between contrasting soil / crop management practices (e.g. Schwartz et al., 2003). Infiltrometer users must maintain complete hydraulic contact between the infiltrometer chamber membrane and the soil. Previous researchers have recommended applying a high permeability material onto the undisturbed soil surface to complete the hydraulic bond between the disc and soil. Some studies have shown that the contact material affects the infiltration because of surface sealing, smearing and clogging of pores. To circumvent these problems, we used the recently developed 'hood infiltrometer' (Schwärzel and Punzel, 2007), to measure crop- and management-induced changes in soil structure.

Study Site

Measurements were conducted at Lincoln University's organic cropping farm, on the Canterbury Plains. The interesting feature of the organic cropping farm is that the crop / pasture rotation is on a two year cycle. This is because of the long intensive cropping history of the site over a number of decades. The present management approach is trying to maintain economic crop production, whilst also trying to rejuvenate the soil's physical fertility. The soil is a well-drained sandy loam, formed in 50 – 100 cm of fine textured alluvium, classified as a Typic Dystrustept (Pallic Soil, type Templeton sandy loam, in the NZ system). Such soils are used predominantly for grazed pasture, with some mixed cropping. The two sites were in adjacent fields on the same soil type. One site had been under grazed pasture for 1.5 years, after being cropped for 2 years. The adjacent site had been cropped for 2 years, after being in pasture for 2 years. Note that the cropping site was loosened / tilled some weeks before the infiltrometer measurements.

Methods

The hood infiltrometer (HI) enables measurement of the hydraulic conductivity, $K(\psi)$, including flow in macropores from saturation down to the bubble point of the soil (Schwärzel and Punzel, 2007), without the need for a contact disc and contact layer. Instead, it places an open water-filled hood, open side down, onto the soil surface (Fig. 1).

Figure 1. Experimental setup at the paddock (Kowhai Organic Farm, Lincoln University)

The HI has three main components: a hood, a Mariotte water supply, and a U-tube manometer (Fig. 2). The first main component is the acrylic hood (diameter = 12.4 cm), placed open-side-down onto the soil with a surrounding retaining ring. The gap between the retaining ring and the hood is sealed with wetted sand to prevent water from leaking out of the side. The hood is connected to a conventional Mariotte water supply (reservoir diameter = 12 cm, length = 71.6 cm), which has a bubble tower placed inside its water reservoir. The bubble tower has an adjustable pipe that controls the suction in the usual way, by allowing air entry at varying distances below the water surface in the tower. In contrast to the infiltration chamber of the conventional disc infiltrometer, an additional air outlet tube connects the air head-space of the water reservoir with the head-space of the hood. The hood also contains a standpipe joined to the U-tube manometer. Its purpose is to measure the effective pressure head on the soil surface, with a precision of 1 mm, from the difference of the height of the water level in the standpipe and the negative pressure head at the U-tube manometer. The zero point of the standpipe scale is at the soil surface. In contrast to the disc infiltrometer, no perforated plate, nylon membrane, or contact material are required on the infiltration surface, which is therefore undisturbed, although the vegetation should be cut to about 5 mm height. For measurements at pressure heads beyond the soil's bubble point, a standard 12.4 cm diameter disc (instead of a hood) can be connected to the Mariotte water supply. Detailed information on the method and data analysis is given in Schwärzel and Punzel (2007).

Hood infiltrometer (HI) measurements were conducted at pressure supply heads of 0, –20, and –40 mm, followed by disk infiltrometer measurements (over exactly the same area measured by the HI) at pressure supply heads of –80 and –120 mm. In some cases at the cropped site, HI measurements at pressure heads of –40 mm were not possible, due to the low bubble point of the soil. Then, disc infiltrometer measurements started earlier, at –40 mm. For the disk experiments we removed all vegetation from the infiltration surface, laid a nylon guard cloth on soil, and prepared a 10-mm thick contact layer using dry spheriglass no. 2227 glass spheres (Potters Ballotini GmbH, Germany). Following all infiltration experiments, we extracted 22 (eleven from each site) undisturbed soil cores, from beneath the positions where the infiltration had been measured. These cores were used to determine (desorption) water retention curves and bulk densities. Also, the carbon content of each sample was measured. Here, we just report on our field infiltration measurements.

Values of the *effective porosity* Φ_e for flow processes associated with pore size classes were calculated according to Watson and Luxmoore (1986):

$$\Phi_e = (8\mu \, \Delta K) \, (g\rho r^2)^{-1} \, 10^2 \tag{1}$$

where μ is the dynamic viscosity of water ($M \, L^{-1} \, T^{-1}$), ΔK is the difference in hydraulic conductivity between two pressure heads ($L \, T^{-1}$), r is the minimum radius for the pore size class considered (L), g is the acceleration due to gravity ($L \, T^{-2}$), and ρ is the density of water ($M \, L^{-3}$). In this study, effective porosities for two pore size classes (PSC) were estimated from the infiltrometer measurements: PSC1, radius≥ 0.50 mm (= macropores); and PSC2, radius 0.50 to 0.15 mm (= mesopores). Using the capillary rise equation, these radii correspond to pressure head ranges of 0 to –30 mm, and –30 to –100 mm.

Results

At each soil surface-applied suction, the geometric mean of hydraulic conductivity of the mixed cropping site was significantly greater than that of the grazed pasture site (Table 1). For instance, the saturated hydraulic conductivity of the cropland exceeded the corresponding pasture site value by 3.8 times. However, with decreasing pressure head, these differences in hydraulic conductivity between the two sites become smaller.

Table 1. Geometric mean values of hydraulic conductivity of the cropland and pasture sites.

Site	Hydraulic conductivity at supply pressure head [mm] 0	- 10	- 30	- 100
	mm s^{-1}			
Mixed cropping	0.0395	0.0299	0.0156	0.0057
Grazed pasture	0.0103	0.0083	0.0052	0.0025

Interestingly, the variability of hydraulic conductivity of the cropped soil was much more pronounced than that of the pasture soil (Fig. 2). The coefficients of variation (CV) between the calculated conductivities of the mixed cropping site and their geometric mean vary between 51 and 63%. For the grazed pasture, the corresponding CVs were between 27 and 29%.

Scholarly Ideas

There are only two kinds of scholars: those who love ideas and those who hate them.

Alain (Emile Chartier) 1868-1951

(French philosopher & author of *About happiness,&c* ...)

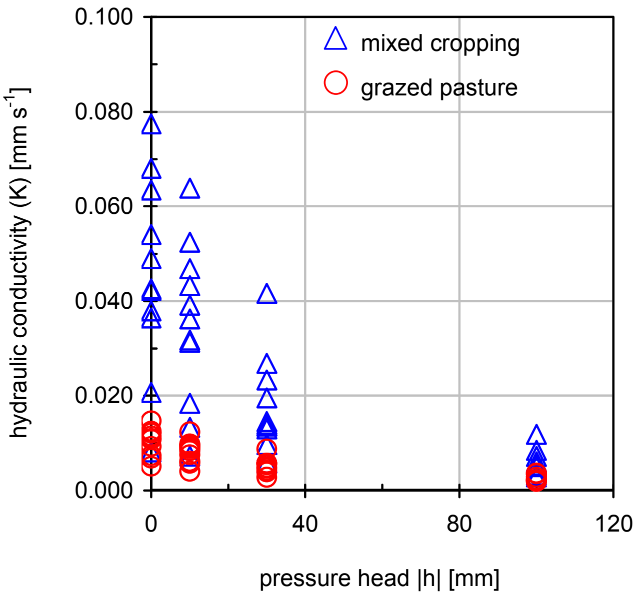

Figure 2. The measured hydraulic conductivities as a function of applied pressure head for the mixed cropping site (blue triangles) and the grazed pasture site (red circles).

The calculated effective porosities of the pore size classes of the cropping and pasture sites are presented in Fig. 3. For the cropped site, the macroporosity (PSC1) and mesoporosity (PSC2) varied from 0.0010 to 0.0240%, and from 0.0285 to 0.2065%, respectively. For the pasture site, the corresponding values were significantly lower (PSC1: 0.0011 to 0.0030% and PSC2: 0.0044 to 0.0283%). Differences in effective porosities as well as in hydraulic conductivities between the two sites may be mainly due to tillage of the cropped soil some weeks before our measurements. Also, to a certain extent, extensive grazing at the pasture site may have induced soil compaction, resulting in a decrease of saturated and near-saturated conductivity compared to the cropped soil.

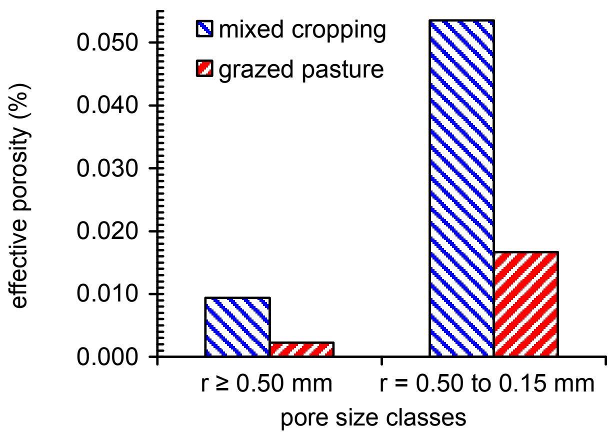

Figure 3. Effective (water-conducting) porosities of the pore size classes versus crop management

Conclusions

Our study verifies that the crop and soil management practices have a large impact on soil hydraulic properties. The hydraulic conductivities as well as the amount of hydraulically active pores of the cropped topsoil were distinctly higher than those of the pasture topsoil. This may be mainly due to the loosening by tillage of the cropped soil some weeks before our measurements. Such soil operations are known to create a loose and fragmented, macropore-rich soil structure. The observed high infiltration rates under the cropped soil indicate that water flow took place between the aggregates rather than through the soil matrix. However, our measurements also show that this created soil structure is unstable. The observed decline in conductivity and effective porosity of the pasture soil compared to the cropped soil can be seen as a loss of aggregate stability due to cropping, resulting in collapse of inter-aggregate pores.

Acknowledgements

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Galluping Climate Change

The Gallup organisation recently conducted a poll of who thinks what about climate change. The public's response to Question 2 - "Do you think human activity is a significant contributing factor in changing the mean global temperature?" was complemented by a survey carried out by the American Geophysical Union, and the results are shown in the graph below (EOS 90(3), 20 January 2009)."

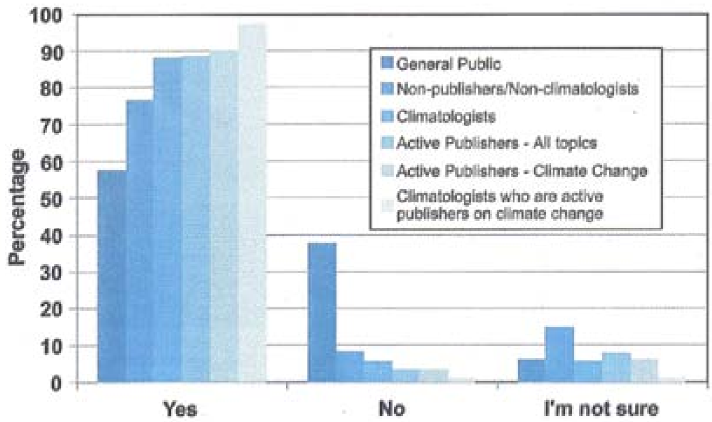
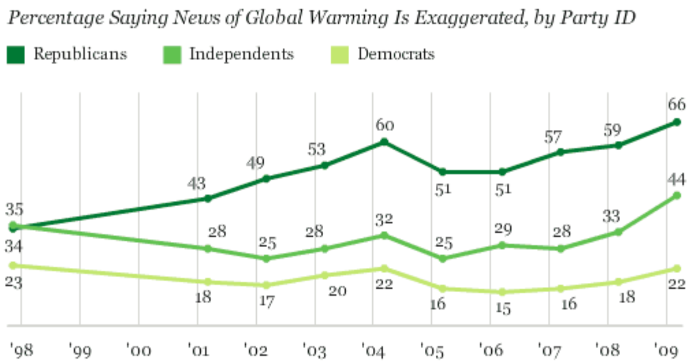


Fig. 1. Response distribution to our survey question 2. The general public data come from a 2008 Gallup poll (see http://www.gallup.com/poll/1615/Environment.aspx).

Continued over page

So whereas 97.4% of climatologists who publish actively on climate change believe that human activity is responsible for temperature rise, just 57 % of the general public do. Ouch!

The Gallup organisation then broke the US general public's response on exaggeration of climate change claims down in relation to voting preference. Their figure is produced below. Phew!



Thank goodness for the recent result of the general election last November

New Series – New Book

The launch of a new series is exciting, and the American Society of Agronomy, the Crop Science Society of America, and the Soil Science Society of America are proud to announce the new book series entitled Advances in Agricultural Systems Modeling. Our Societies believe that future breakthroughs in science and technology lie at the boundaries of disciplines, and this series is intended to encourage transdisciplinary and interdisciplinary research and its synthesis to solve practical problems.

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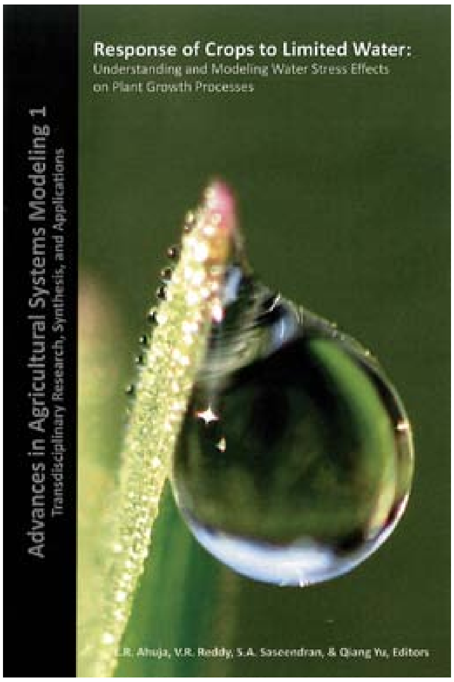

Response of Crops to Limited Water: Understanding and Modeling Water Stress Effects on Plant Growth Processes is an excellent first book in this series. We believe that this book will be of great importance to all scientists, modelers, and students working in water-limited crop production systems. The cast of internationally known authors has done an excellent job of synthesizing the state-of-the-science in a straightforward and instructive manner. The volume should be of particular value for graduatelevel teaching. The Societies appreciate the efforts of series editor Dr. Laj Ahuja, who assembled an impressive group of authors and developed a thoughtful book, with the indispensable synthesis that is missing from many similar titles. We also thank co-editors V.R. Reddy, S.A. Saseendran, and Qiang Yu.

The questions for the world are: How can irrigated agriculture sustain productivity and meet the growing need for food and fiber with reduced water available for irrigation? What research knowledge and technologies are needed to accomplish this sustainability?

The answers lie, along with other supporting measures, in simultaneously achieving: the conservation of both rain and irrigation water

- in the field by managing to cut losses from runoff, deep percolation, and evaporation
- the preservation of the quality of groundwater and soil by preventing salinity development and nitrate and pesticide pollution
- achieving increased water use efficiency of crops by optimizing irrigation with respect to rainfall, critical growth stages, soil fertility, and weather conditions; smart allocation of limited water among crops; and advantageous selection of crops by region, with selection of alternate crops in drought years

These goals will require a whole-system quantitative approach to guide management and achieve optimization of water application and crop performance, while protecting water quality and the environment. The computer models of agricultural systems are the essential technology needed for this purpose. The system modeling technology will also help conserve and make the most use of rainwater in rainfed agricultural areas, including water-limited cropping or forage–livestock systems. These areas comprise about 60% of the agriculture in the world. Prolonged drought in the last few years has especially stressed these dryland areas. The farmers and ranchers need simple tools to manage the systems during droughts. These tools can be derived from system models.

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Gen Y Goes to Work

From *The Economist* December 30, 2008 … The global downturn has been a brutal awakening for the youngest members of the workforce—variously dubbed "the Millennials", "Generation Y" or "the Net Generation" by social researchers. "Net Geners" are, roughly, people born in the 1980s and 1990s. Those old enough to have passed from school and university into work had got used to a world in which jobs were plentiful and firms fell over one another to recruit them. Now their prospects are grimmer.

This is creating new problems for managers. Because of the downturn, Net Geners are finding it harder to hop to new jobs. At the same time, their dissatisfaction is growing as crisis-hit firms adopt more of a command-and-control approach to management—the antithesis of the open, collaborative style that young workers prefer. Less autonomy and more directives have sparked complaints among Net Geners that offices and factories have become "pressure cookers" and "boiler rooms".

Indeed, Net Geners may be just the kind of employees that companies need to help them deal with the recession's hazards. For one thing, they are accomplished at juggling many tasks at once. For another, they are often eager to move to new roles or countries at the drop of a hat—which older workers with families and other commitments may find harder to do. Such flexibility can be a boon in difficult times.

Compromises will have to be made on both sides. Younger workers will have to accept that in difficult times decisions will be taken more crisply and workloads will increase. Their managers, meanwhile, will have to make an extra effort to keep Net Geners engaged and motivated.

WHO PRODUCES **WISPAS?**

WISPAS is produced by a team of four, namely the Editor and two Regional Correspondents who cover news and activities from their respective research communities and nearby institutions, plus Christine Lamont who prepares the copy and mails WISPAS out. If you have any material that you think may be suitable for the next issue of WISPAS please contact your nearest Regional Correspondent or the Editor. WISPAS is published by Plant & Food Research.

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