Supplemental Material

Nutrient Leaching in a Colombian Savanna Oxisol Amended with biochar

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Supplemental Material includes Methods and three figures.

Supplemental Methods

Measurement of soil surface infiltration

Surface water infiltration was measured using a serrated stainless steel infiltration surface with a diameter of 22 mm (Mini Disk Infiltrometer model S by Decagon Devices, Inc. Pullman WA, USA). For all infiltration trials the suction of the device was set to 20 mm (Decagon, 2011). Measurements were done at four different locations between rows inside each replicated plot. A thin layer of quartz sand was applied to the soil to ensure good contact. The height of the water column was measured at time 0, and repeatedly after placing the filled infiltrometer on the soil at times 10 s, 20 s, and then at 20 s intervals until 280 s had passed, at which time all infiltration experiments reached steady state within the measurement intervals used (Boxell and Drohan, 2009). This yielded a total of 12 infiltration measurements per treatment and measurement date.

Before infiltration measurements were made on a plot, the volumetric water content of the surface soil was measured in each replicate plot at three randomly selected locations between the crop rows. Volumetric water contents were estimated using a hand-held frequency domain reflectometry (FDR) probe (model ML2 connected to HH2 display by Delta-T Devices, Cambridge, UK). For the last infiltration measurement date, the FDR probe was damaged and soil water contents were determined gravimetrically using destructive soil sampling in one location per plot.

Measurements with the double ring infiltrometer made use of nested rings with diameters of 0.58 and 0.28 m which were inserted at one location inside each replicated plot. Water was added to both rings and the water level in the inner ring was measured at 16 time points over 2 h, at which point steady state was reached within the measurement intervals. No soil water content data are available for this infiltration measurement.

Hydraulic conductivity at the surface was calculated for each disk infiltrometer trial using the following equation (Zhang, 1997):

$$I = C_1 t + C_2 t^{1/2}$$

where I (m) is cumulative infiltration, t (s) is time, C_2 (m $s^{-1/2}$) is a constant related to soil sorptivity (Zhang, 1997) and C_1 (m s^{-1}) is related to hydraulic conductivity (k) by the following equation:

$$k = C_1/A$$

Parameter A is a value relating the van Genuchten parameter (Carsel and Parrish, 1988) for the soil type to the suction rate and radius of the infiltrometer disk, in this case A=4.4 (Decagon, 2011). For a few of the measurements, this calculation method could not be used because C_1 was a negative value. In these cases, the method proposed by Vandervaere et al. (2000) was employed, which allows the effect of contact sand to be visualized and removed from the data. The value of C_1 was then determined using the equation:

$$dI/dt^{1/2} = C_2 + 2\ C_1 t^{1/2}$$

Infiltration data obtained from the double ring infiltrometer were used to determine hydraulic conductivity by plotting cumulative infiltration against time, and applying a linear regression to the portion of the data corresponding to steady-state infiltration (Reynolds et al., 2002).

References

Boxell, J. and P.J. Drohan. 2009. Surface soil physical and hydrological characteristics in *Bromus tectorum* L. (cheatgrass) versus *Artemisia tridentata* Nutt. (big sagebrush) habitat. Geoderma 149:305-311.

Carsel, R.F. and R.S. Parrish. 1988. Developing joint probability distributions of soil water retention characteristics. Water Res. Res. 24: 755-769.

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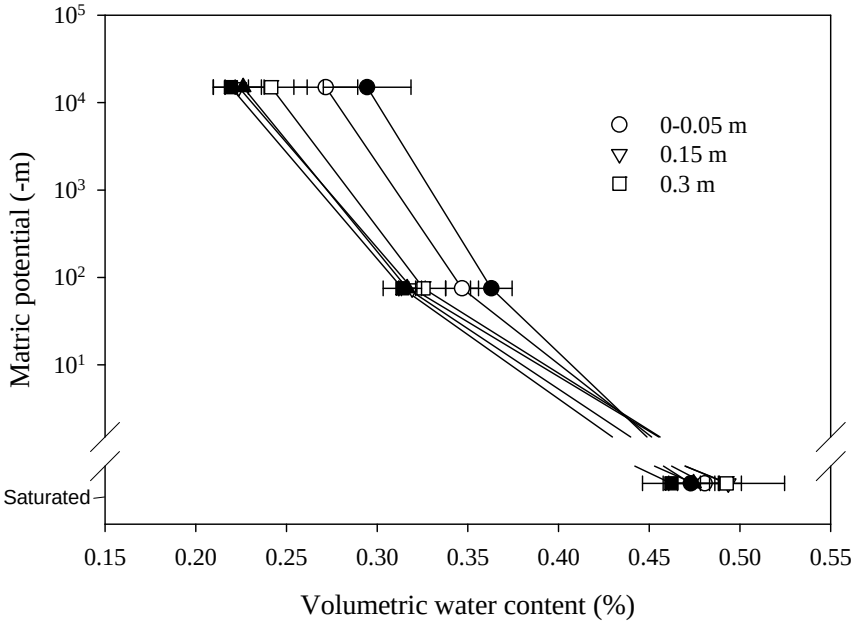
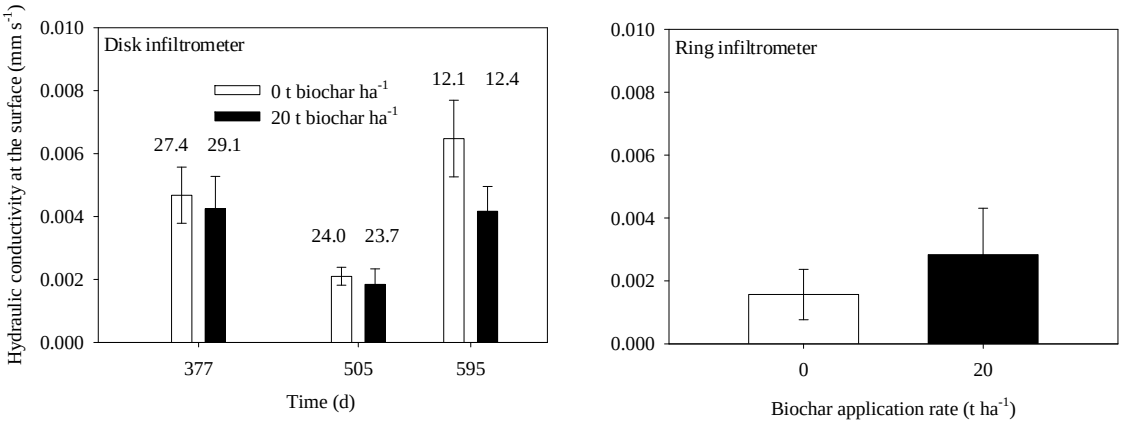
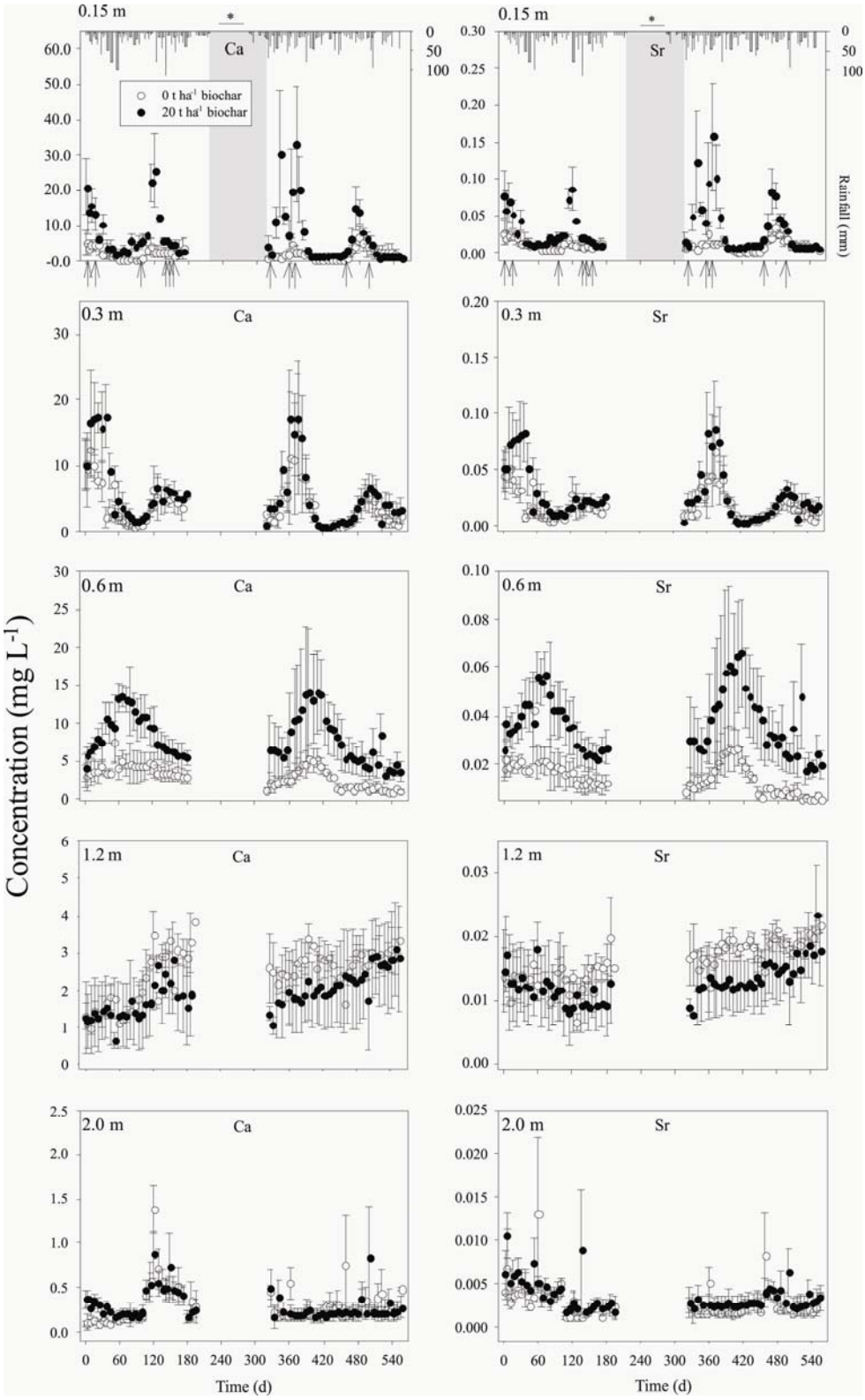
Zhang, R. 1997. Determination of soil sorptivity and hydraulic conductivity from the disk infiltrometer. Soil Sci. Soc. Am. J. 61:1024-1030.



Supplemental Fig. S1. Soil moisture retention curves for samples taken at various depths from plots receiving 0 (open symbols) or 20 t biochar ha^{-1} (closed symbols) (*n*=4).



Supplemental Fig. S2. Surface hydraulic conductivity measured with a disk infiltrometer (left panel, ± SE, *n*=12) and a double-ring infiltrometer (right panel, ± SE, *n*=3) on a Colombian savanna Oxisol during the fourth year after biochar application. Numbers above bars show the surface soil's percent volumetric moisture content at the time of measurement.



Supplemental Fig. S3. Concentrations of Ca and Sr in soil solution collected using suction cup lysimeters from a Colombian savanna Oxisol which had received 0 or 20 t ha^{-1} of biochar, three years

before sampling started. Error bars represent standard errors (*n*=3). Rainfall is shown with bars. Arrows indicate fertilization events, and the shaded area shows the dry season between two cropping periods. Note the different scales on y-axes. *: rainfall data missing for the period shown.