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Comparison between three soil solution samplers in a sandy soil of Northeast Thailand

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Introduction

The sandy soils of the uplands are the most prone to nutrient leaching, especially under tropical conditions. Measuring the concentrations of the elements in the soil water of the vadose zone remains however difficult. The usual method of sucking the soil solution using ceramic cups under depression is not adapted, because of the two difficulties of applying the suction at the right time and being able to pick up a fast-moving pulse.

The objective of the study was to compare three different soil samplers (PVC plates, Tensionics instruments and fibreglass wicks) for their ability to collect soil water samples, for the dispersion of the results obtained and for the composition of the solution collected.

Material and methods

The PVC plate samplers were made of a 50 X 20 cm PVC plate 3 mm thick bent to make a small gutter along the longest dimension. The gutter was connected to a plastic tube to collect the samples. A plastic mesh was installed between the sampler and the plastic tube to prevent the soil particles being carried away with the water. The samplers were inserted slightly obliquely from a profile by opening a slot with a knife and back-filling the gap between the sampler and the soil with the original soil. The profile was kept open during the experiment.

The Tensionic instrument (Moutonnet *et al.*, 1993) is made of a small closed ceramic cup around 2 cm id and 5 cm long (around 12 mL) glued at the base of a PVC tube, which makes the instrument look like a regular tensiometer. The ceramic cup remains filled with water at any time, so the composition of the water inside the ceramic equilibrates with the soil solution by diffusion. Capillary tubes inserted in the ceramic cup allow for the water samples to be withdrawn from the instrument and distilled water to be reinserted afterwards. Previous experiments had shown that the instrument needed around one week to equilibrate (Moutonnet *et al.*, 1992) and that the results obtained with the Tensionic instrument to measure nitrate leaching in a clayey soil were not different from those obtained with ceramic cups under suction (Poss *et al.*, 1995). The tensionic instruments were inserted in the soil after drilling a hole slightly smaller than the diameter of the Tensionic instrument in order to get good contact between the porosity of the ceramic and the soil.

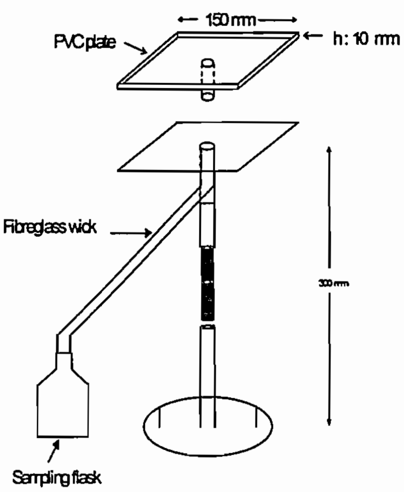

Figure 1 Fibreglass sampler

The fibreglass wick sampler (Boll *et al.*, 1992) consists of a 15 X 15 cm plate on which fibreglass is spread (Figure 1). This plate is connected through a central hole to a 0.8 m-long fibreglass wick inserted in a plastic tube installed as vertically as possible in the soil. The containers receiving the soil solution were kept in a pit opened around 50 cm apart from the sampler.

The experiment was carried out on the very sandy (5% clay) arenic Acrisol of the Nam Phong series in Northeast Thailand. The samplers were installed in five 8X6 m plots that had received 650 kg ha^{-1} lime as $Ca(OH)_2$ and 1500 kg ha^{-1} gypsum in the 0-15 cm layer one month before the start of the experiment as part of a factorial experiment. Each plot was equipped with one sampler of each type, except one plot that received two Tensionic instruments and two fibreglass samplers (total of 5 PVC plates, 6 Tensionic instruments and 6 fibreglass samplers). All the samplers were installed at 20 cm depth. The measurements were made during two years with the Tensionic instruments and the fibreglass wicks, but only during the first year for the PVC plates. The first year was wet, which allowed the collection of many samples, but the second year was very dry, so few samples could be collected.

The PVC plates and fibreglass samplers were collected after each rain event and the volume of each sample measured. The samples were filtered through a Whatman 42 paper filter and stored frozen. Individual samples collected during a fortnight were bulked together. Tensionic instruments were collected every fortnight and the samples kept frozen until analysed.

Nitrate was determined by colorimetry with a Technicon AutoAnalyzer II after reduction to nitrite by passing through a column of copperized cadmium. Calcium and magnesium were measured by atomic absorption spectrometry with a Shimadzu 670 Atomic Absorption Spectrophotometer, using $SrCl_2$ to correct for interference.

Results and discussion

Number and volume of the samples collected

The number of the samples collected with the PVC plates was always lower than 2, whilst the rate of success of the fibreglass wicks was 65% (Table 1). Samples could be collected regularly from the Tensionic instruments every fortnight.

Measurements made with TDR instruments and tensiometers (data not shown) have proved that most drainage below 20 cm appears within 24 hours after the rain events and that the absolute value of the suction at 20 cm was always higher than 30 hPa for three years. These results suggest that the water is moving fast in this soil type and that this movement happens under capillary forces, not as free water. This could explain the low number of samples obtained with the PVC plates, as only free water can be collected with the PVC plates.

The volume collected by the fibreglass wick samplers per square meter was much higher than the one collected by the PVC plates. This result shows the effect of the suction of the wick on the rate of extraction of soil water.

Table 1. Number and volume of the samples collected during one year

	3 Jun	13 Jun	18 Jun	14 Aug	16 Aug	2 Sep	3 Sep	**Average**
Number of samples								
PVC plates (5 samplers)	0	2	1	0	1	1	2	**1.0**
Tensionic (6 samplers)	6	-	6	6	-	-	6	**6.0**
Fibreglass (6 samplers)	2	2	5	5	4	5	4	**3.9**
Volume collected (L m^{-2})								
PVC plates	-	2.9	0.2	-	1.7	0.7	1.1	**1.3**
Fibreglass	4.7	0.2	5.0	4.7	1.9	5.9	4.0	**3.8**

Composition of the water samples

Only results from the Tensionic instrument and the fibreglass wick will be discussed, as very few samples were collected from the PVC plates.

The electrical conductivity decreased sharply with time, following the leaching of gypsum during the rainy season (Figure 2). The electrical conductivity was consistently higher in the water from the fibreglass wicks than from the Tensionic instruments. The same held for the few samples collected the following year (data not shown).

The dispersion of the results was high (coefficients of variation higher than 68%) for both samplers (Table 2). A higher dispersion of the values from the Tensionic instrument could have been expected, as the size of the sampler was smaller. The fact that they are comparable suggests that the spatial heterogeneity of the composition of the soil solution was higher at the scale of the field than at the scale of the sampler.

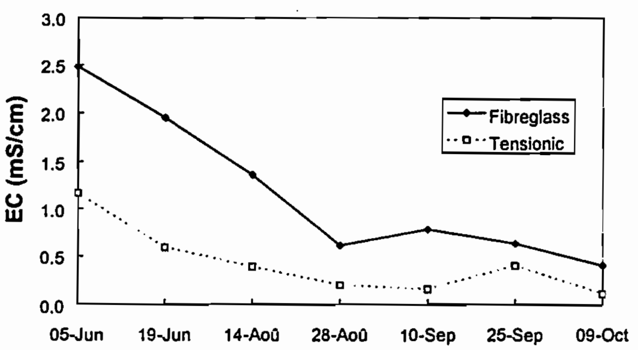

Figure 2 Evolution of the electrical conductivity with time

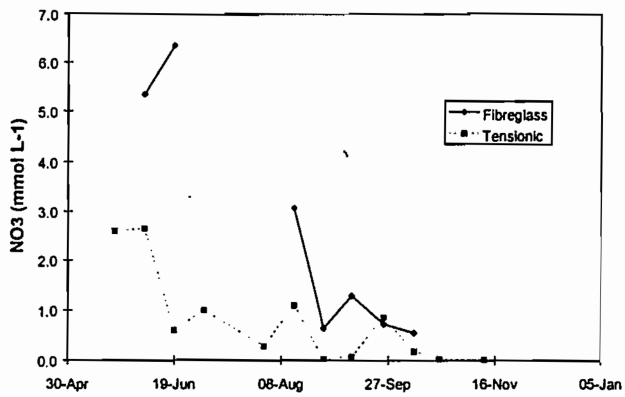

Figure 3 Evolution of the NO3 content in the soil solution with time

Table 2 Average coefficients of variation of the composition of the soil solution collected with fibreglass samplers and Tensionic instruments (%)

	Nitrate	Calcium	Magnesium
Fibreglass	69	94	81
Tensionic	89	68	73

The nitrate content of the solution collected with the fibreglass samples was statistically higher than that collected with the Tensionic instrument, for all dates but 25 September (Figure 3). For calcium and magnesium the values from the fibreglass sampler were consistently higher than the values from the Tensionics, but the difference was not statistically different, due to the high coefficient of variation.

This study shows that, unlike the previous paper on the use of the Tensionic instrument, the electrical conductivity and the nitrate content of the soil solution obtained with the Tensionic instrument were consistently lower than those obtained with the fibreglass samplers. As the dynamics of the soil water are fast, the peak of concentration moves quickly downwards. The results suggest that the fibreglass samplers were able to pick up these peaks. As the Tensionic instrument needs one week to equilibrate, this instrument was unable to monitor the fluxes of nutrient in this soil type.

Conclusion

The PVC plate samplers were unable to sample the soil solution in the vadose zone of the sandy soil studied. The fibreglass samples allowed to take soil solution samples with a rate of success of 65%. The Tensionic instrument permitted to take soil solution samples throughout the year.

The coefficients of variation of nitrate, calcium and magnesium were between 68 and 94% for the fibreglass and the Tensionic instrument, without difference between the samplers. As spatial heterogeneity of the field may be high, this study cannot conclude whether or not there is a difference in the coefficient of variation between the samplers.

The concentrations measured with the Tensionic instrument were consistently lower than those measured with the fibreglass sampler. This result was interpreted as the result of the inability of the Tensionic instrument to pick up fast moving pulses, because of the time it needs to equilibrate. The fibreglass samplers seem to be an interesting option to measure leaching in sandy soils in undisturbed conditions.

References

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ONZIÈME RÉUNION DU GROUPE DE RÉFLEXION

SUR L'ÉTUDE DE LA SOLUTION DU SOL

EN RELATION AVEC L'ALIMENTATION DES PLANTES

(GRESSAP)

IRD Montpellier - 14 septembre 1999