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A MODIFIED HYDROPNEUMO-ELUTRIATION APPARATUS FOR QUANTITATIVE ROOT SEPARATION FROM LARGE SOIL CORE SAMPLES

Jean Luc Jean-Yves
J. L. Chotte[1], J. Y. Laurent, and J. P. Rossi

Centre ORSTOM de Fort de France BP 8006, 97259 Fort de France cédex, Martinique, West Indies

ABSTRACT: An apparatus was designed to separate roots automatically from large soil samples (>20 kg). The apparatus (1.50 m height) was constructed of polyvinyl chloride pipes (diameter = 100 mm). The roots were separated from soil mineral particles at the base of the apparatus by a high energetic hydrovortex, and then transfered to a 200-µm sieve by a flow of water and small air bubbles. The inlet flow of both water and air were ajusted to obtain roots similar to those separated by hand (control). The statistical analysis indicated that 7 out of 42 tested pairs of water and air flows gave results not significantly different from the control. The inlet water flow is fixed to 3 L/min and the air inlet to 100 units for routine analysis. The washing cycle is completed in 5 minutes for 200 g of soil, but for larger soil samples, it could be extended over several hours after evacuating the mineral particules from the base of the apparatus.

INTRODUCTION

The different methods for *in situ* quantitative root measurement have already been reviewed (Boehm, 1979). These methods can be divided in two main categories: e.g. destructive soil-root interaction methods and non-destructive soil-root interaction methods. The latter involve observing roots in soil behind glass windows (Pearson and Lund, 1968; Roberts, 1976) or glass tubes (Sanders and

1. Present address: CSIRO, Division of Soils, Private Box No. 2, Waite Road, Glen Osmond, S.A. 5064 Australia.

Brown, 1978; Brown and Upchurch, 1987; Smucker et al., 1987). Glass tubes or minirhizotrons are designed to quantify root biomass and root growth under field conditions and to measure the spatial variability of the main root parameters: e.g. root lenght density and root diameter (Cheng et al., 1991; Parker et al., 1991). Despite their number of uses in agriculture, these techniques are not yet fully perfected (Bragg et al., 1983; Maertens, 1987; Parker et al., 1991). Among the destructive soil-root interaction methods, the core sampling method is commonly used. This method provides accurate results, but separation and hand-removal of roots from soil are time-consumming and labor-intensive. Several automated washing machines have been tested for rapid quantitative root separation from soil samples (Fribourg, 1953; Fehrenbacher and Alexander, 1955; Cahoon and Morton, 1961; Brown and Tilhenius, 1976; Smucker et al., 1981). The method proposed by Smucker et al. (1981) consists of a maniflod of nine hydropneumatic-elutriation units constructed of PVC in which roots, presoaked for 16 hours in a $Na(PO_3)_6$ solution (50 g/L), are separated from the soil by water spray, and then removed by flotation by small air bubbles. The entire wash cycle requires from 3 to 10 minutes for nine samples of 125 g each.

This study, which was part of a research program dealing with the turnover of soil organic matter in tropical grasslands, reports on the efficiency of a modified version of the apparatus described by Smucker et al. (1981). This apparatus was adapted for quantitative root separation from large soil core samples (>20 kg) and for the separation of 1,000-200 mm roots which represents the most time-consuming work.

MATERIALS AND METHODS

Description of the Apparatus

The hydropneumatic-elutriation apparatus was constructed of polyvinyl chloride pipes fitted together (Figure 1) so that it can be easily dismantled for cleanning. A soil sample was brought into the washing chamber (Figure 1B) by unit A (Figure 1A) consisting of a 100 to 40 mm reducer and a 40 mm diameter tube assembly. In the washing chamber (diameter = 150 mm), soil was dispersed by a high energy hydrovortex produced by two vertical rows of eight pressurized jets of water (diameter = 500 μm). Roots and organic debris were separated from coarse mineral particles (>200 μm) by flotation in a flow of small air bubbles produced from 10 holes (diameter = 500 μm) in an horizontal tube. The mineral particles remaining at

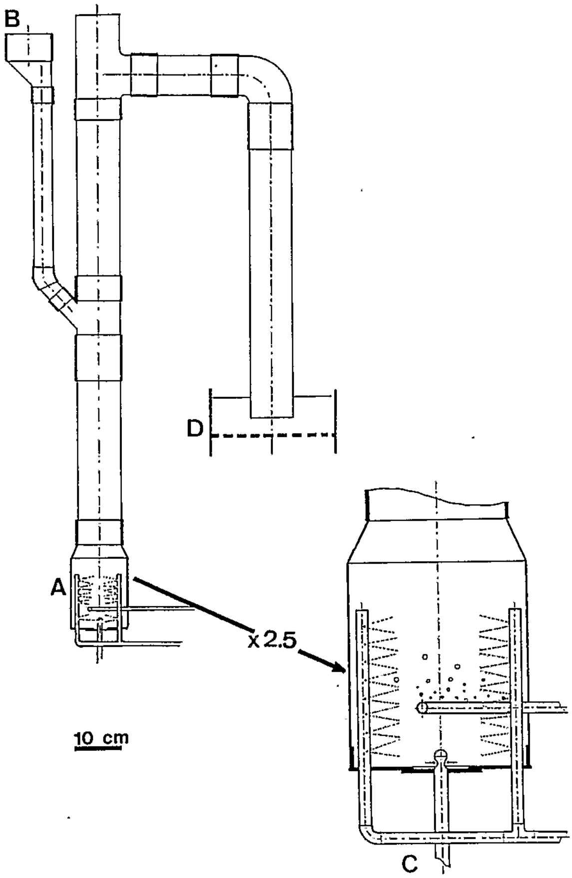

FIGURE 1: Scheme of the apparatus.

the base of the washing chamber could be evacuated through an exhaust even during the operation of the apparatus (Figure 1C). Pneumohydro-elutriated organic materials are collected on a sieve (200 µm) (Figure 1D). Inlet flows of both air and sampled after aerial plant harvest. The soil was air dried and homogenized. Two hundred grams of soil were presoaked over night in a solution of NaOH (0.10N at pH 10) to enterely disperse the soil (Feller et al., 1991) and then sieved at 1 mm to collecte the organic residues larger than 1 mm. The soil (<1-mm) was used for the calibration.

The control treatment consisted of handsorting the roots (>200 µm contained in the soil <1 mm) by sieving at 200 µm and flotation in water.

Statistical Analysis

The dry weight (RW) and percentage of the weight loss on ignition at 950°C (I%) of the roots 200-1,000 mm separated by pneumohydro-elutriation were compared with those of the same roots isolated by hand.

Seven air flows (AF = 10, 20, 40, 70, 100, 150, and 200 expressed in an arbitrary unity) and six water flows (WF = 2, 3, 4, 6, 8, and 11 L/min) were tested in different combinations (42 pairs). Triplicate soil samples were analysed for each couple (AF/WF) and four replicates for the control treatment.

The effect of the treatments on both the root dry weight (RW) and the weight loss-on-ignition (I%) was assessed by means of a one way ANOVA. A comparison test was made with Fisher's least significant difference test (Sokal and Rholf, 1981) to identify treatments leading to mean values non significantly different from results obtained in the control.

RESULTS

One-way ANOVA indicated that treatments effects on both the root dry weight (RW) and the weight loss-on-ignition (I%) were highly significant ($p = 0.0001$; F-test, $u = 5\%$) in each case. RW and I% varied with respect to air and water flow values. Water flows higher than 4 L/mm always lead to large departure from control values both for RW (Figure 2) and I% (Figure 3).

The Fisher's least significant difference test showed that: i) water flow of 3 L/min associated with air flow of 20, 40, 70, 100, and 150, and ii) water flow of 2 L/min associated with air flow of 100 and 200 gave results not significantly different from the control. Among the possible regulations of the apparatus, the air flow of 100 associated with either water flows of 2 L/min or 3 L/min gave the closest values to control (Figure 2). We propose to use the water flow of 3 L/min and eliminate the flow of 2 L/min to not use the apparatus in the flow limits. For routine analysis, water and air flows are, respectively, fixed at 3 L/min and 100 units.

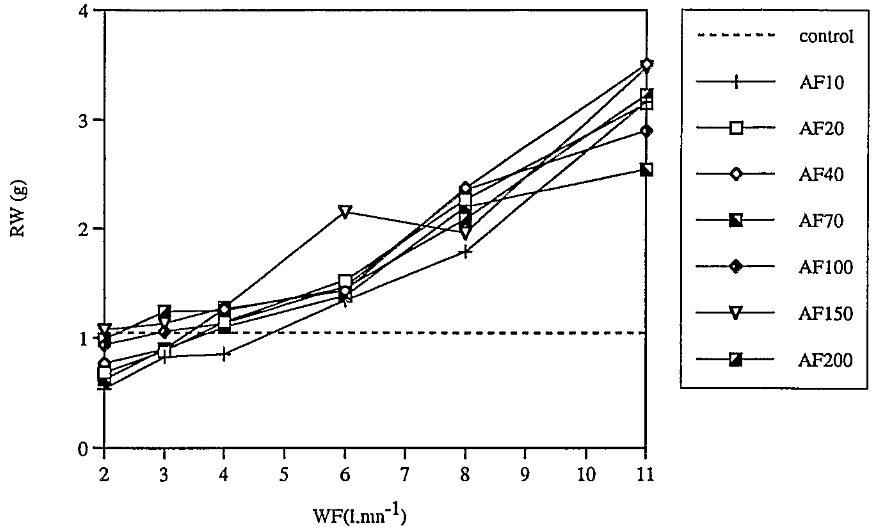

FIGURE 2: Weight of the roots 200–1000 μm

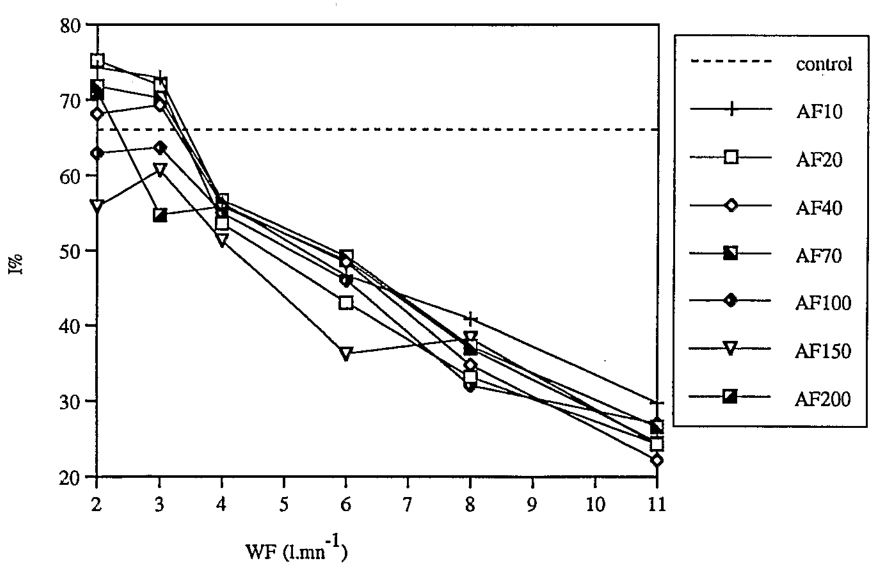

FIGURE 3: Weight loss on ignition (I%) of the roots 200–1000 μm

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