自動土壌溶液サンプラーの砂丘畑不飽和土壌への適用
Application of an automated infiltration soil water sampler in unsaturated sandy soil

○東　直子*・森　也寸志**・猪迫　耕二***・井上　光弘*
Higashi Naoko*, Mori Yasushi**, Inosako Koji*** and Inoue Mitsuhiro*

1. Introduction

Accurate measurement and sampling of infiltration water from the root zone are necessary to understand soil and groundwater contamination processes. An automated soil water sampler, which consists of a sampling device with filter, automated vacuum system (AVS)[1)~4)] and tensiometers, was developed to measure the infiltration water flux in a sandy soil. Filters and sampling conditions were examined for effective collection of soil water.

2. Materials and Methods

2-1.Automated infiltration soil water sampler： Selection of bottom filter and boundary condition was very problematic because dune sand allows quick drainage with small suction change. Glass, stainless, and membrane filters of different pore sizes were examined to select the bottom filter for sandy soil. The AVS[2)3)] automatically applied regulated suction according to the monitored suction head (h_L and h_R), so that h_c was close to them and the device collected infiltration water without disturbing the soil water profile. Clogging test was also conducted using muddy water from washed Tottori dune sand.

2-2.Column experiment for estimating water collecting efficiency (WCE)： Tottori dune sand was packed under wet condition (bulk density:1.55 Mg/m^3)in the column (PVC pipe, 20 cm-i.d.×105 cm-height). The WCE was examined by installing the sampling device with glass filter (G4) at 50 cm depth (Fig.1). Time domain reflectometry sensors and tensiometers were inserted to the column at 5 depths to monitor soil water condition. Three tensiometers used for suction control were inserted at 47.5 cm depth. An artificial rainfall system supplied distilled water at a constant flux (*qi*). At first, it was 2 mm/h continuously, and then water supply was stopped to establish a drier condition. Following this drought, water was supplied three times (Run1~3) with different rainfall intensity (Table2). The each Run was started 2 hours before the rainfall. When vertical water content (θ) profile in the column returned to the initial condition, a Run was finished and the next Run was started. Suction at the bottom of the column was

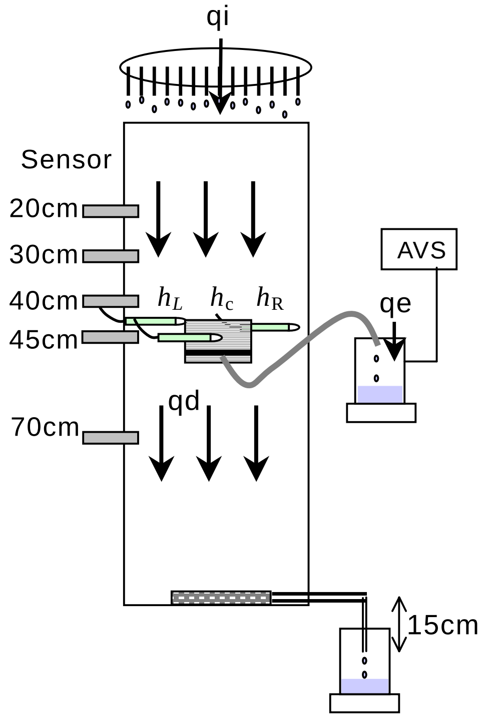

Fig.1　Schematic illustration of the column experiment.

*鳥取大学乾燥地研究センターALRC, Tottori Univ.**島根大学生物資源科学部 Life and Environmental Science, Shimane Univ. ***鳥取大学農学部 Agriculture, Tottori Univ. キーワード：下方浸透,土壌溶液採水

set as 15 cm. The collected water flowed into the desiccator through the water filled tube, and sampling points was set at the same depth with filter.

3.Results and Discussion

3-1.Filter selection： G3 and G4 filter had high permeability and their air entry values were under 100 cmH_2O (Table1). Membrane filters were easily clogged by muddy water. Stainless filters were sometimes clogged when repeatedly used. Glass filter, especially G4 filter was hard to be clogged, easy to handle, and effective.

Table 1. Saturated hydraulic conductivity and air entry value of filters

Filter	Pore size (μm)	Hydraulic conductivity (cm/s)	Air entry value (cmH_2O)
Glass (G5)	2~5	1.4×10^{-4}	300
Glass (G4)	5~10	5.8×10^{-4}	90
Glass (G3)	20~30	2.1×10^{-3}	40
Stainless	2	1.9×10^{-4}	180*
Stainless	5	2.4×10^{-4}	180*
Membrane	1.2	1.4×10^{-5}	400*
Membrane	3	1.6×10^{-5}	200*
Membrane	5	1.5×10^{-5}	350*

* Data from catalog

3-2. Column experiment： When water was supplied continuously with 2 mm/h (θ = 0.30 cm^3/cm^3), the sandy soil above the filter surrounded by sidewall was easily wetted. Matric pressure head above the filter (h_c) was constantly higher than the surround ones [$h_{LR}= (h_L+h_R)/2$] and infiltration water was collected effectively by applying a constant suction of 15 cmH_2O. Under drying condition after stopping the water supply, h_c, h_L and h_R were stable (-49~-54 cmH_2O). Following this drought, water was supplied with different rainfall intensity. Total rainfall quantity, cumulative drainage from the column, and cumulative sampling quantity in each Run were defined as Qi, Qd and Qe, respectively. Water balance (WB) in column [WB = (Qe+Qd)/Qi], was 99~106% because evaporation loss and additional storage were small. WCE(%) was estimated from *qe*/*qd*. Qe was divided by area of sampling filter, which was defined as *qe*. Qd was divided by the difference between area of column and area of sampling filter, and which was denoted as *qd*. When ($h_c - h_{LR}$)≧-5 cm after a rainfall, suction was regulated to 0~39 cmH_2O by AVS and infiltration water was collected with a WCE of 125~141 % in each Run (Table 2). It is necessary to prevent the momentary incorrect determination of suction control by the three tensiometers.

Table 2. Water collecting efficiency from various rainfall intensities.

	Initial water content θ (cm^3/cm^3)	qi (mm/h)	qd (mm)	qe (mm)	**WCE (%)**	WB (%)
Run1 (48h)	0.16±0.02	20	34.4	43.9	**127.6**	106.2
Run2 (72h)	0.11±0.01	10	22.1	31.0	**140.8**	98.6
Run3 (74h)	0.12±0.02	2	16.2	20.3	**125.3**	103.5

4.Conclusion

G4 filter was selected as the best filter for water sampler in an unsaturated sandy soil. Infiltration water was collected most effectively using our sampler when sampling tube was filled with water and suction was controlled at 0~39 cmH_2O by AVS. WCE was 125~141% during a short-term rainfall.

References: 1) van Grisven, et.al (1988) Soil Sci.Soc.Am. J.52: 1215-1218. 2) M.Inoue and C.Dirksen (2000) Proceeding of JSIDRE annual meeting, 636-637.3) Y.Nakao,et.al (2003) Proceeding of JSIDRE annual meeting. 4) K.Kosugi and M. Katsuyama (2004) Soil Sci. Soc. Am.J.68: 371-382.