Supplementary Material

**Supplementary Table 1.** Ion concentrations of the solutions used in the experiment (Unit: mg∙L−1).

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| Solution | Concerned ion | Concentration (mg∙L-1) |
| Two-point normalization solution (high) | Ca | 248.03 |
| K | 308.91 |
| NO3 | 981.7 |
| Two-point normalization solution (low) | Ca | 28.37 |
| K | 35.39 |
| NO3 | 100.9 |
| Stock solution 1 (Ca(NO3)2∙4H2O) | Ca | 3489.11 |
| NO3 | 11243.6 |
| Stock solution 2 (KH2PO4) | K | 6450.5 |
| P | 4149.582 |
| Stock solution 3 (NH4H2PO4) | NH4 | 3340.28 |
| P | 4732.319 |
| Stock solution 4 (KNO3) | K | 7627.55 |
| NO3 | 13564.3 |
| Stock solution 5 (NH4NO3) | NH4 | 4430.25 |
| NO3 | 16608 |
| Stock solution 6 (MgSO4∙7H2O) | Mg | 2071.4 |
| Stock solution 7 (K2SO4) | K | 8857.83 |
| pH control solution (H2SO4) | H | pH 2.0 |
| Tap water | Ca | 16.13-23.4 |
| K | 2.66-3.51 |
| NO3 | 5.9-9.2 |
| P | 0.113-0.136 |
| Mg | 3.24-4.77 |
| NH4 | Not detected |
| SO4 | 3.24-15.6 |

Supplementary Table 2.. Specifications of components of the ion-specific management system.

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| Component | Specification | Manufacturer/Model |
| Sample chamber | A chamber of Poly(methyl methacrylate): 100 mL | Megascience (Seoul, South Korea), Sensor chamber |
| Sensor array | K ISE Measuring range: 3-700 mg·L-1 Detection limit: 3 Response time: ~50sNO3 ISE Measuring range: 3-1600 mg·L-1 Detection limit: 3 Response time: ~50sCa ISE Measuring range: 3-700 mg·L-1 Detection limit: 3 Response time: ~50sReference electrode: Double-junction  | K, NO3: Laboratory-madeCa: Thermo Fisher Scientific (MA, USA), 9320BNReference: Thermo Fisher Scientific (MA, USA), 900200 |
| Sampling & drainage pumps | Peristaltic pump Flow rate: 0.22 L·min-1 Tubing material: SiliconInner tubing diameter: 1.6 mm Power: 24 VDC | ASF THOMAS (Puchheim, Germany), SR10/50 |
| Stock solution pumps | Peristaltic pump Flow rate: 0.1 L·min-1 Tubing material: NovopreneInner tubing diameter: 1.6 mm Power: 24 VDC | ASF THOMAS (Puchheim, Germany), SR10/50 |
| Water replenishment pump | Peristaltic pump Flow rate: 0.525 L·min-1 Tubing material: SiliconInner tubing diameter: 4.8 mm Power: 24 VDC | BOXER (Ottobeuren, Germany), QQ15 |
| Nutrient solution supplying pump | Centrifugal pumpFlow rate: 33.3 L∙min-1 Maximum pressure height: 10.19 kgf∙cm-2Power: 3PH 380 VAC | Hwarang System Co., Ltd. (Incheon, South Korea), PP50Y |
| Main control system | CPU: 3.4 GHz (i7 4770, Intel)Memory: DDR3 8gbOS: Window 7Main program: LabVIEW (v2015, National Instruments, TX, USA) | Hewlett-Packard (CA, USA), EliteDesk 800 G1 TWR |
| Solution tanks | Two-point normalization solutions (5 L for each) | Korea First Safety (Incheon, South Korea), 5L HDPE (high density polyethylene) tank |
| Stock solutions (2 L for each) | Korea First Safety (Incheon, South Korea), 2L HDPE (high density polyethylene) water tank |
| Nutrient solution mixing tank (Max. 100 L) | Bestplastic (Gyeonggi-do, South Korea), 100L PE (polyethylene) water tank |
| Water-level sensor | Reflective Ultrasonic Level TransmittersMeasurement range: 0.038-1.5 mAutomatic temperature compensation: -40-80 °CSignal output range: 4-20 mAPower: 24 VDC | Flowline, Inc. (CA, USA), EchoPod UG01 |
| Data acquisition board | A/D converter for ISE signalsInput channel: 16 bit analog inputSampling rate: 250 kS∙s-1  | National Instrument (TX, USA), PCI-6221 |
| Signal conditioner | Isolated analog input board for ISEsInput range: ± 10 V Gain: 1 | National Instrument (TX, USA), SCC-AI13 |
| Relay | Solid state relayInput voltage range: 0~60 VDCOutput voltage range: 0~60 VDCChannel: 8 ch.  | National Instrument (TX, USA), NI-9485 |