

Supplementary Information

Mechanoadaptive root growth in *Medicago sativa* under controlled microhydrodynamic environments

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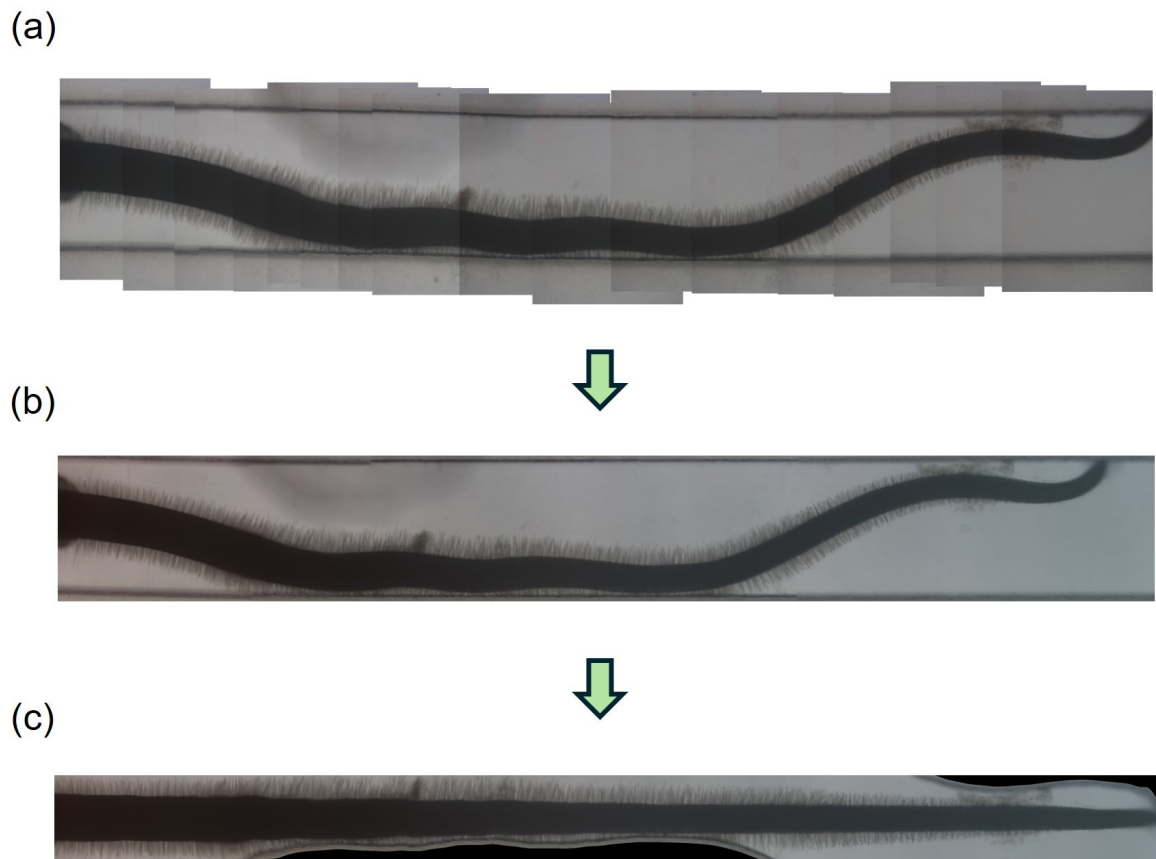
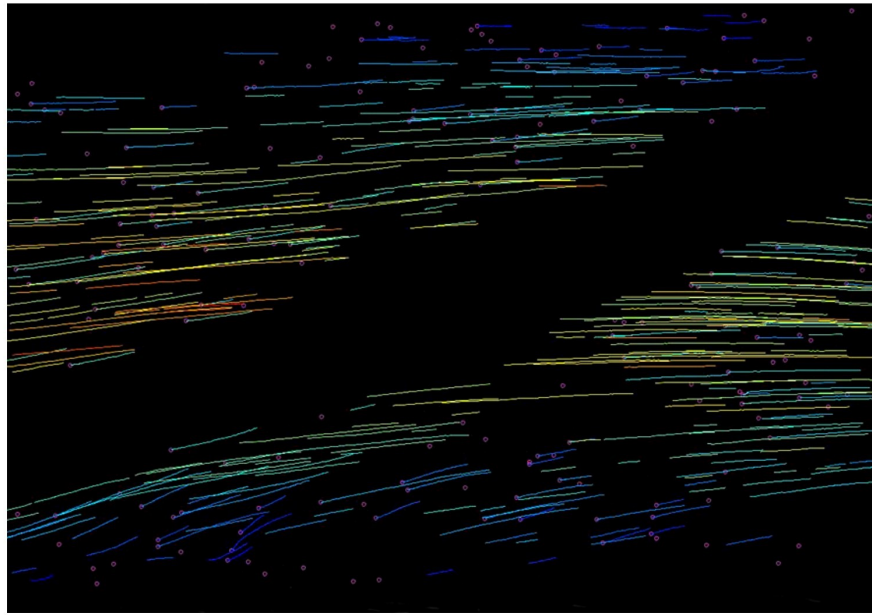


Fig. S1 Process of image merging and root straightening. (a) Sequential images of *Medicago sativa* roots. (b) Sequential images merged into a single image using Image Composite Editor and MosaicJ software. (c) The root straightened using an ImageJ macro

(a)



(b)

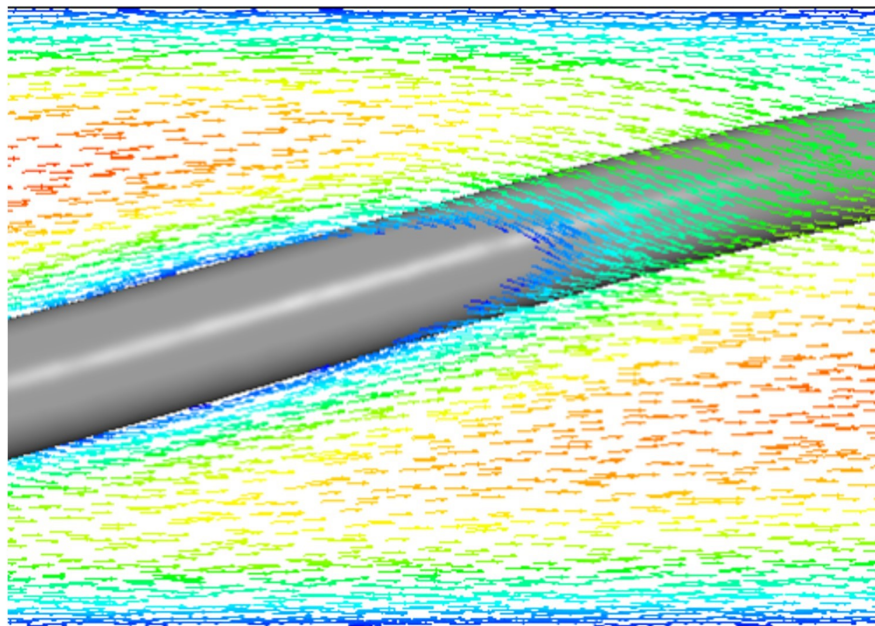


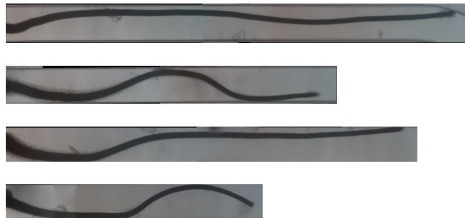
Fig. S2 Validation of the computational fluid dynamics (CFD) results. (a) Visualization of particle tracking within the channel. *Medicago sativa* root located in the middle of the channel. Pathlines are presented by ImgaeJ software. (b) Vector field obtained from CFD results. The results exhibit a high degree of similarity to the visualization of particle tracking, supporting the validity of the CFD results

(a)

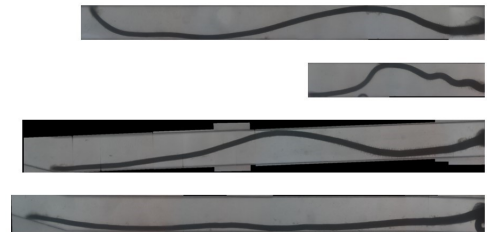
Inlet flow rate: 100 $\mu\text{L}/\text{min}$

Flow direction \rightarrow

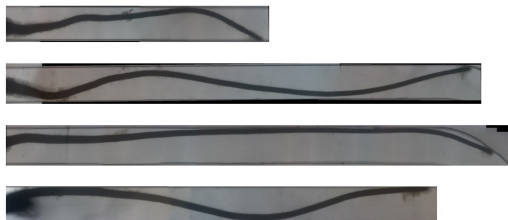
Channel: A



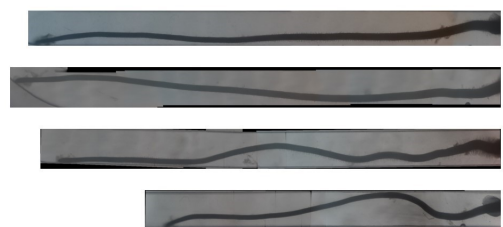
D



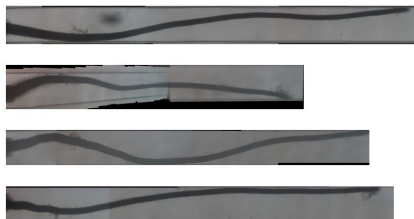
B



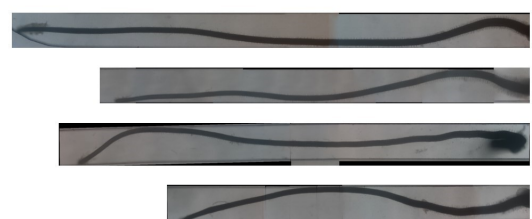
E



C



F



2 mm

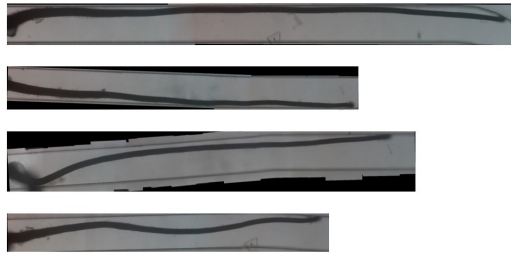
Fig. S3 Merged *Medicago sativa* roots images of inlet flow rate of (a) 100, (b) 50, (c) 10, (d) 5, (e) 1, and (f) 0.1 $\mu\text{L}/\text{min}$, and (g) control group. Scale bar represents 2 mm. Channels A, B, and C are the forward group, in which the roots grow along the direction of fluid flow, and Channels D, E, and F are the reverse group, in which the roots grow opposite to the direction of fluid flow

(b)

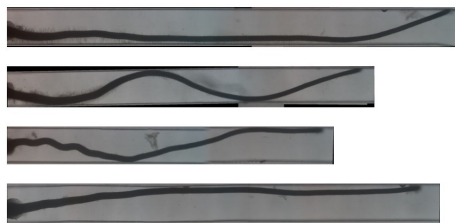
Inlet flow rate: 50 $\mu\text{L}/\text{min}$

Flow direction \rightarrow

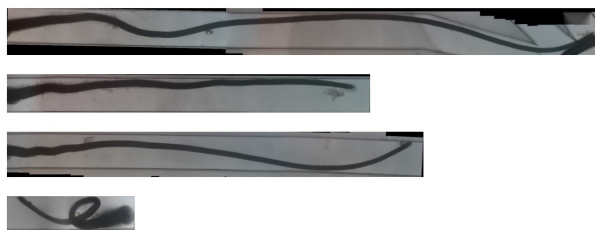
Channel: A



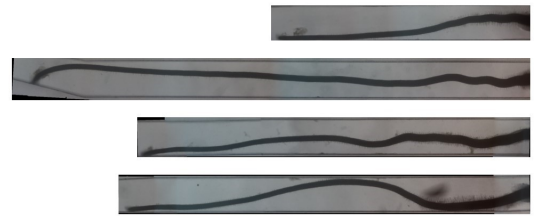
B



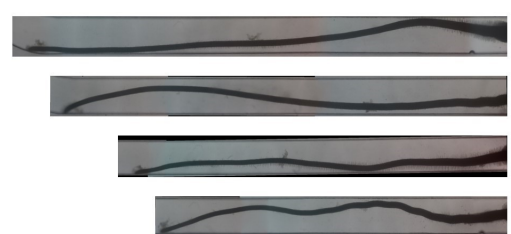
C



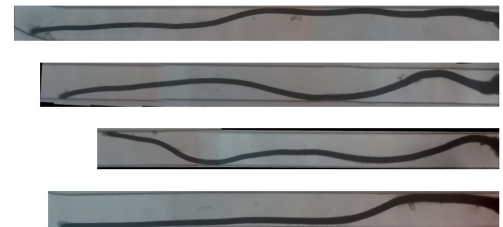
D



E



F



2 mm

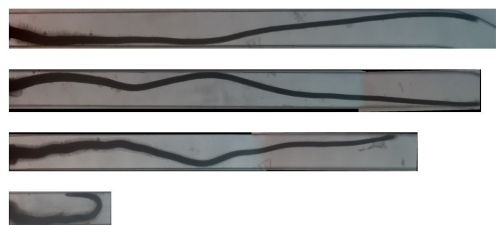
Fig.S3 (Continued)

(c)

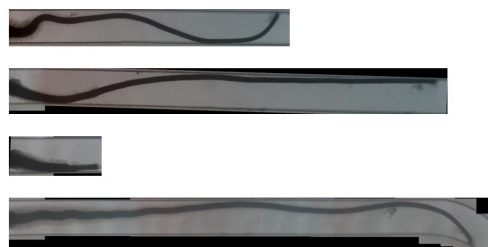
Inlet flow rate: 10 $\mu\text{L}/\text{min}$

Flow direction \rightarrow

Channel: A



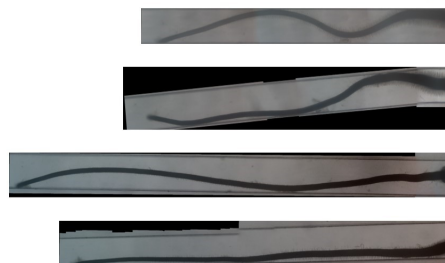
B



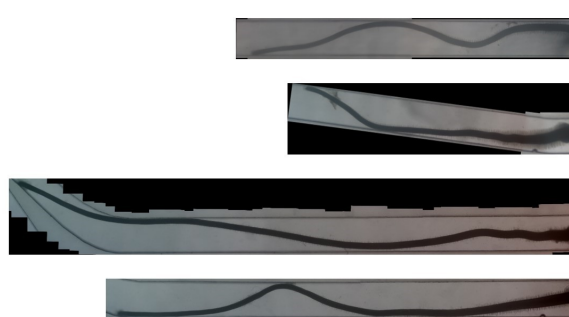
C



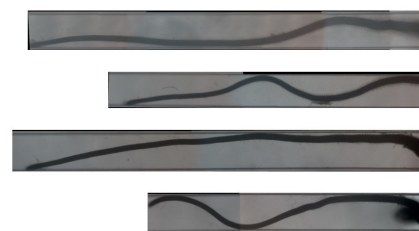
D



E



F



2 mm

Fig.S3 (Continued)

(d)

Inlet flow rate: 5 $\mu\text{L}/\text{min}$

Flow direction \rightarrow

Channel: A

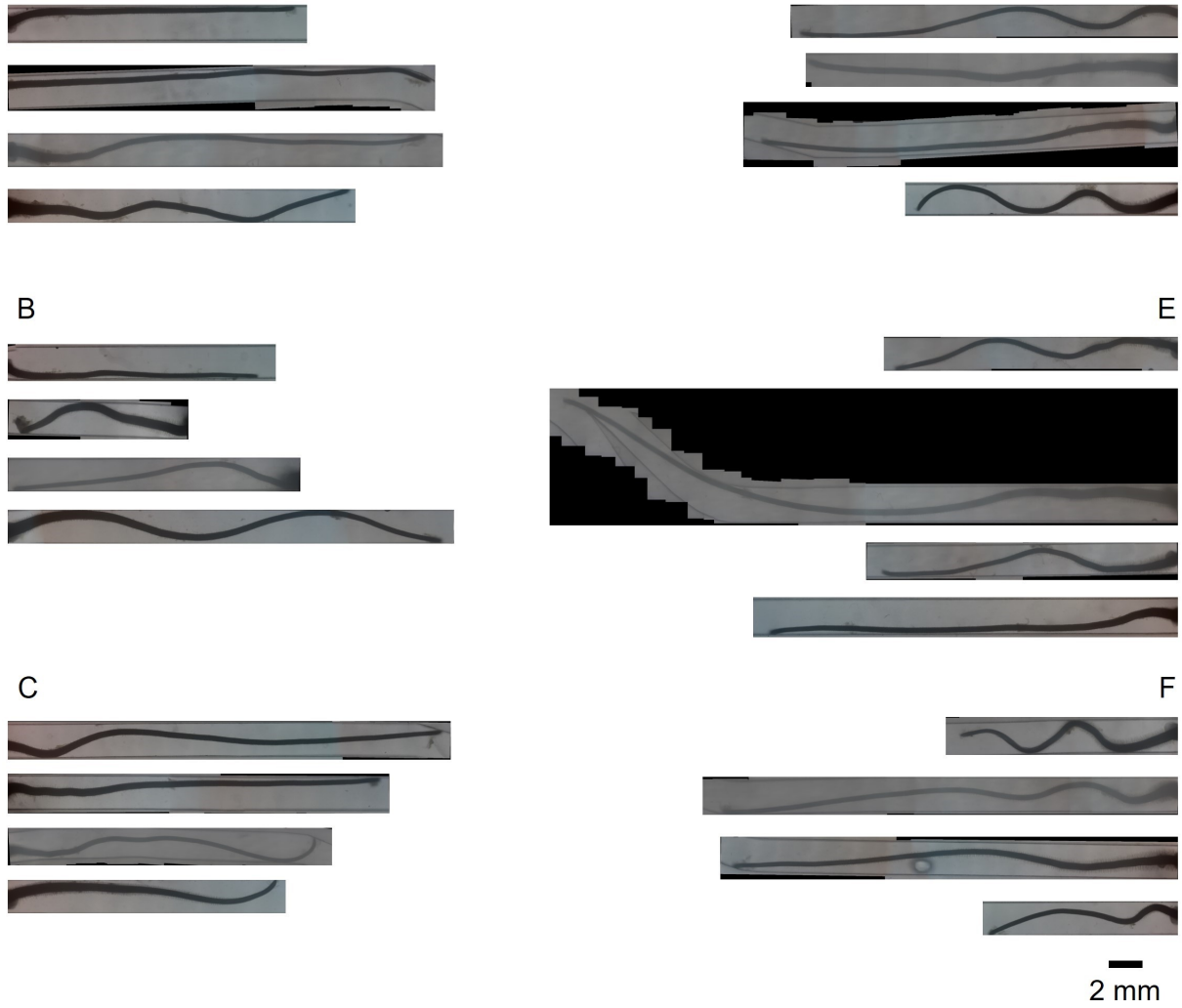


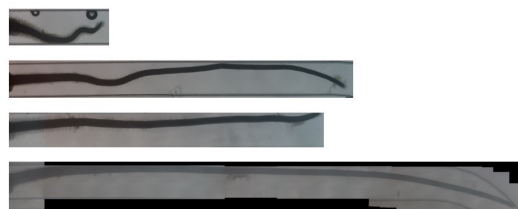
Fig.S3 (Continued)

(e)

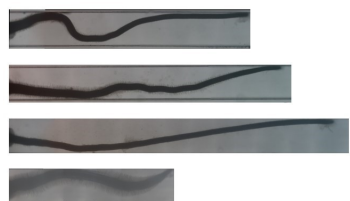
Inlet flow rate: 1 $\mu\text{L}/\text{min}$

Flow direction \rightarrow

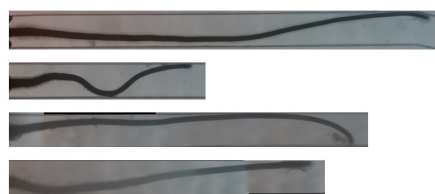
Channel: A



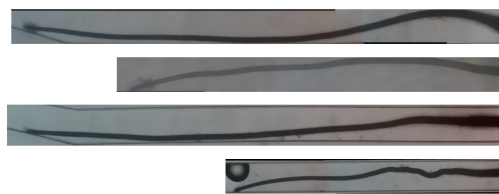
B



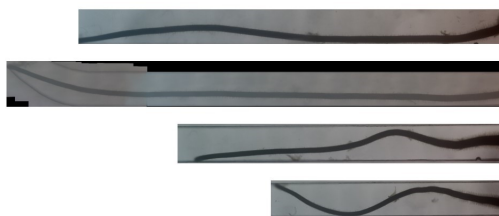
C



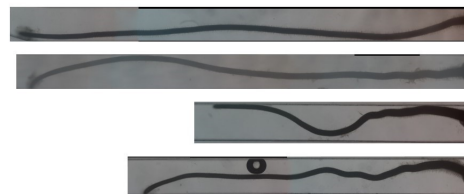
D



E



F



2 mm

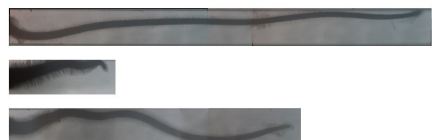
Fig.S3 (Continued)

(f)

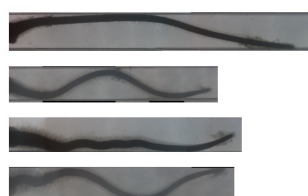
Inlet flow rate: 0.1 $\mu\text{L}/\text{min}$

Flow direction \rightarrow

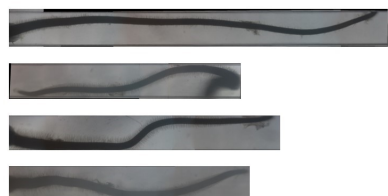
Channel: A



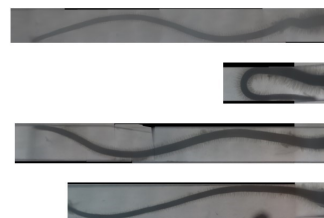
B



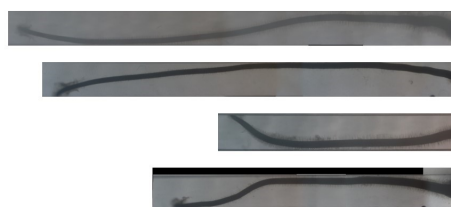
C



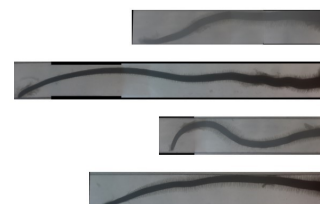
D



E



F



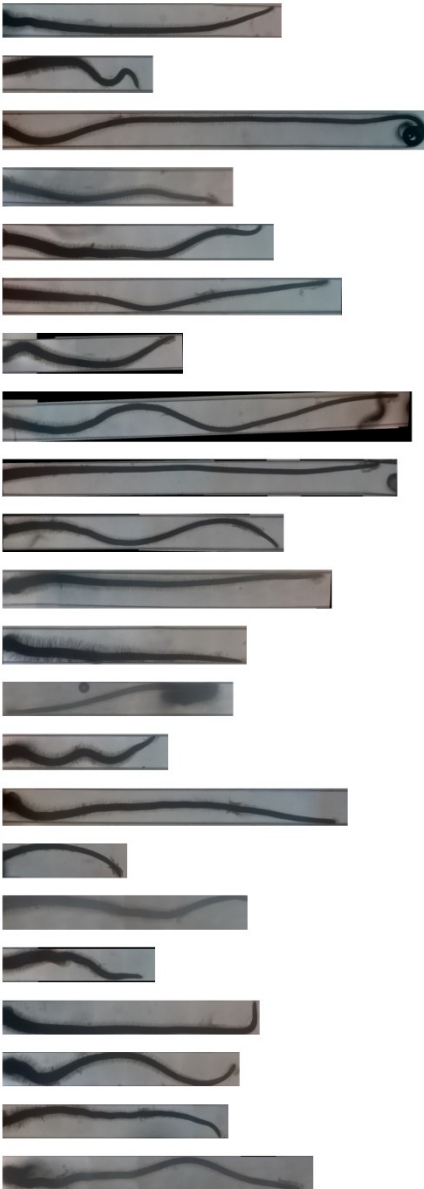
2 mm

Fig.S3 (Continued)

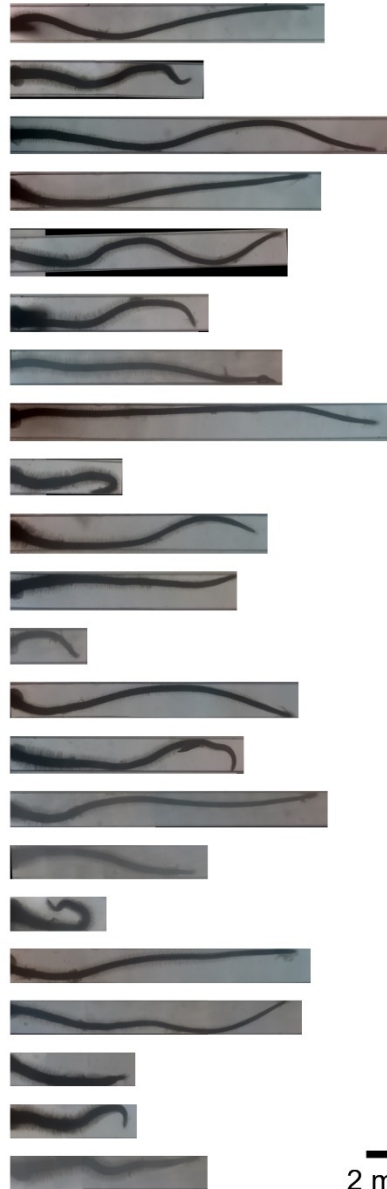
(g)

Control group

CON1



CON2



2 mm

Fig.S3 (Continued)

(a) Forward group

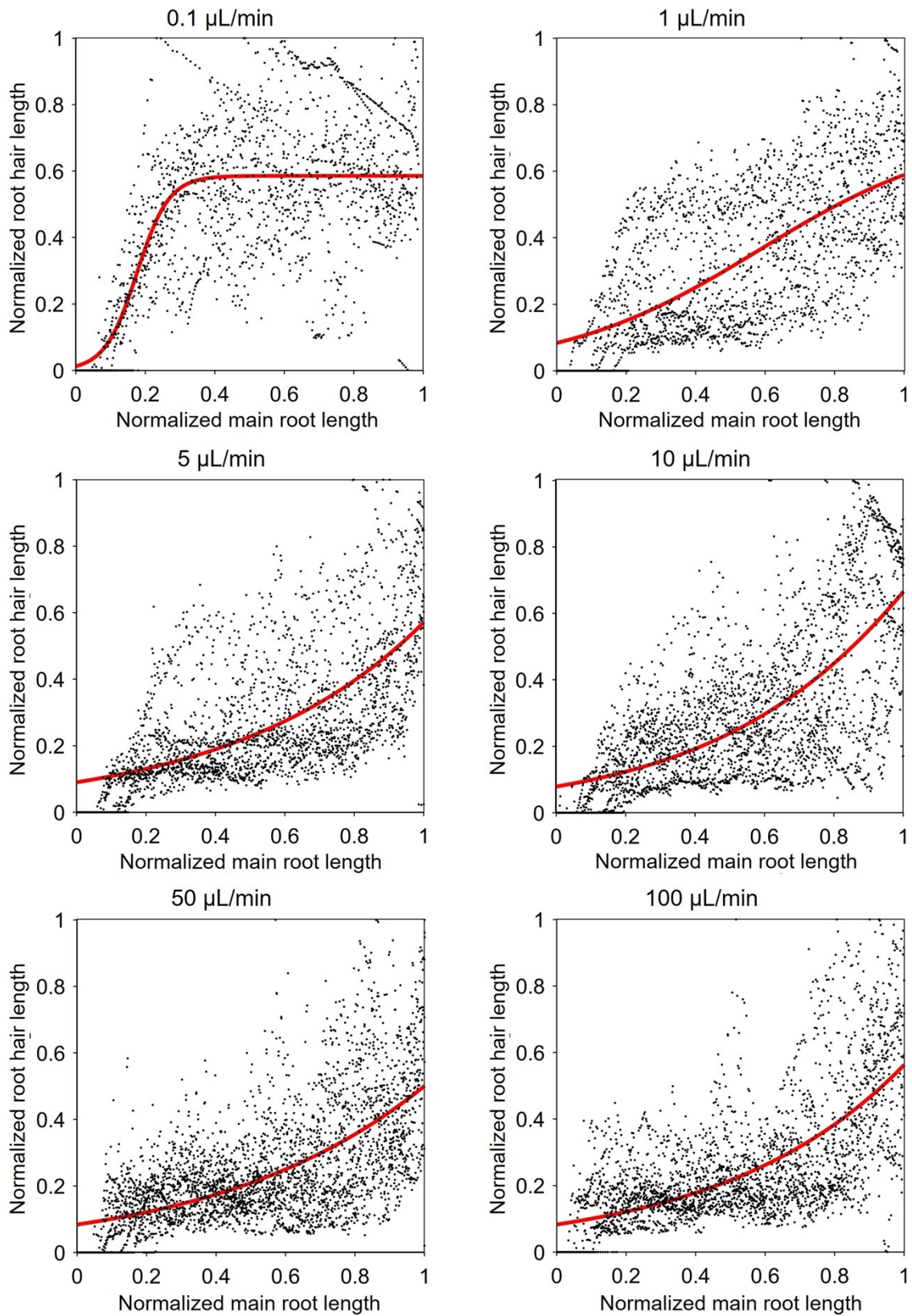


Fig. S4 Distribution of root hair length for (a) forward, (b) reverse, and (c) control groups. Min-max normalization is used. Black dots and red lines represent root hair length data and fitted curves, respectively

(b) Reverse group

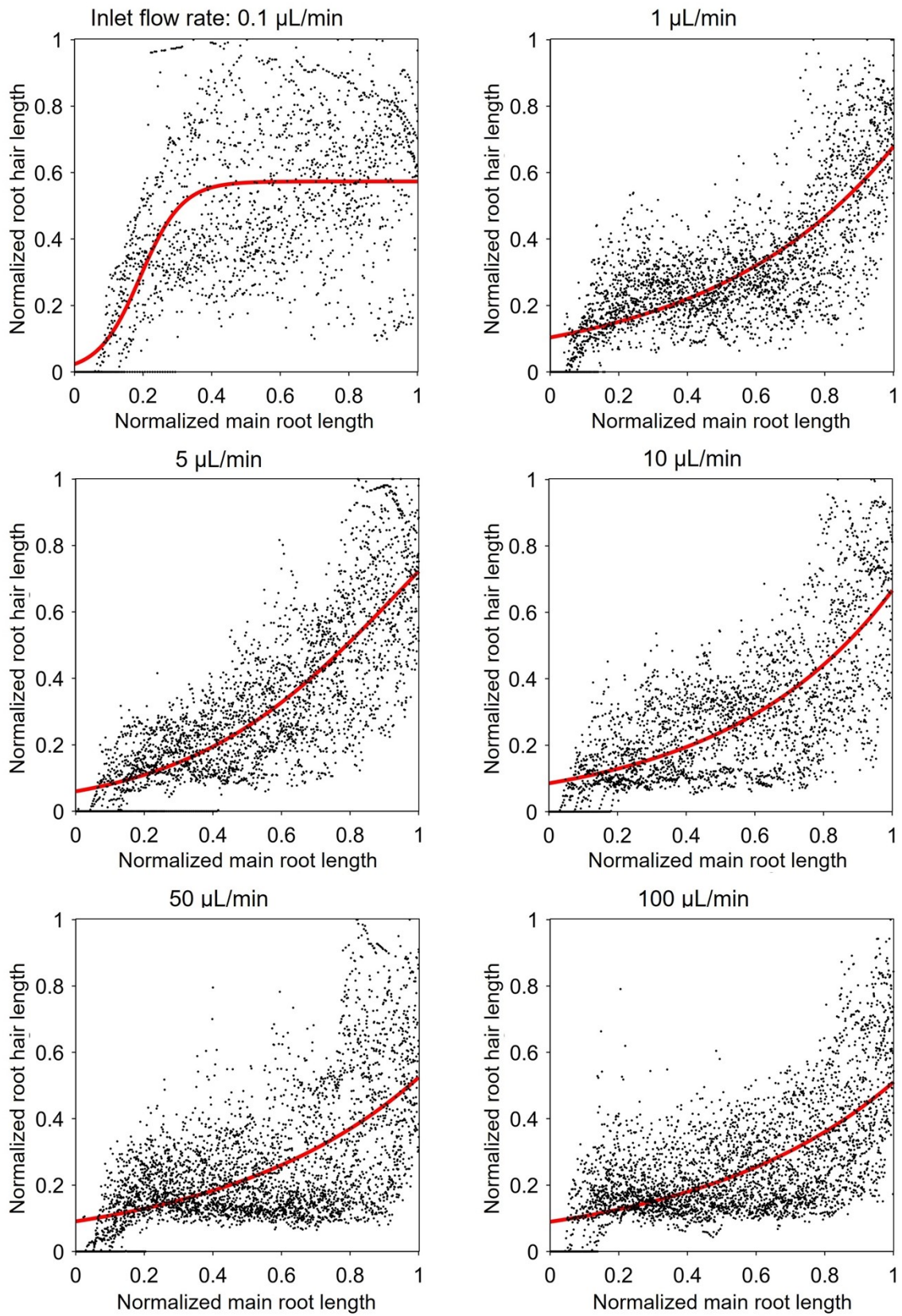


Fig.S4 (Continued)

(c)

Control group

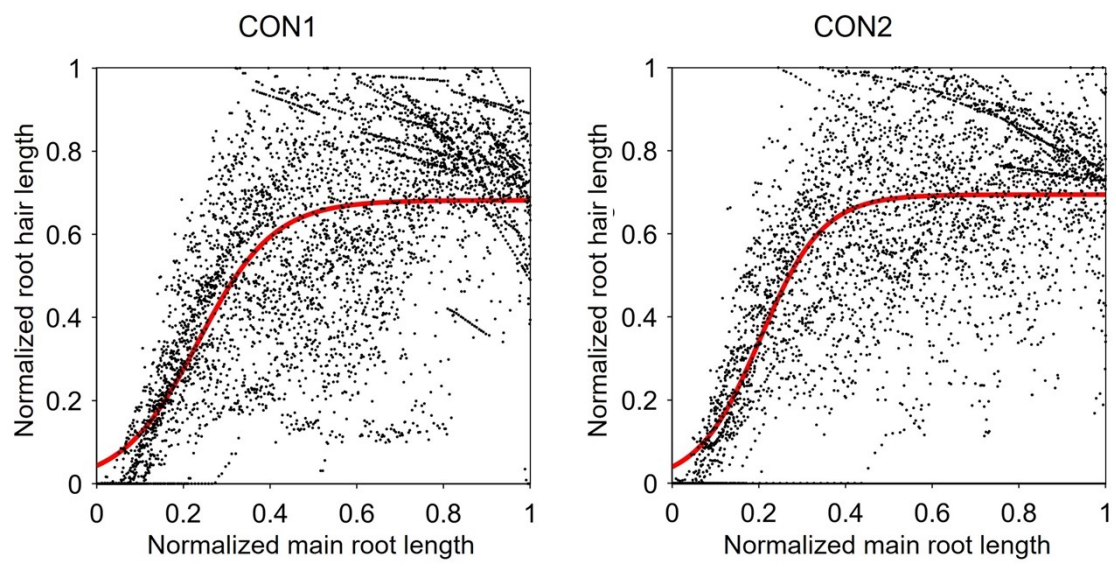


Fig.S4 (Continued)

(a) Forward group

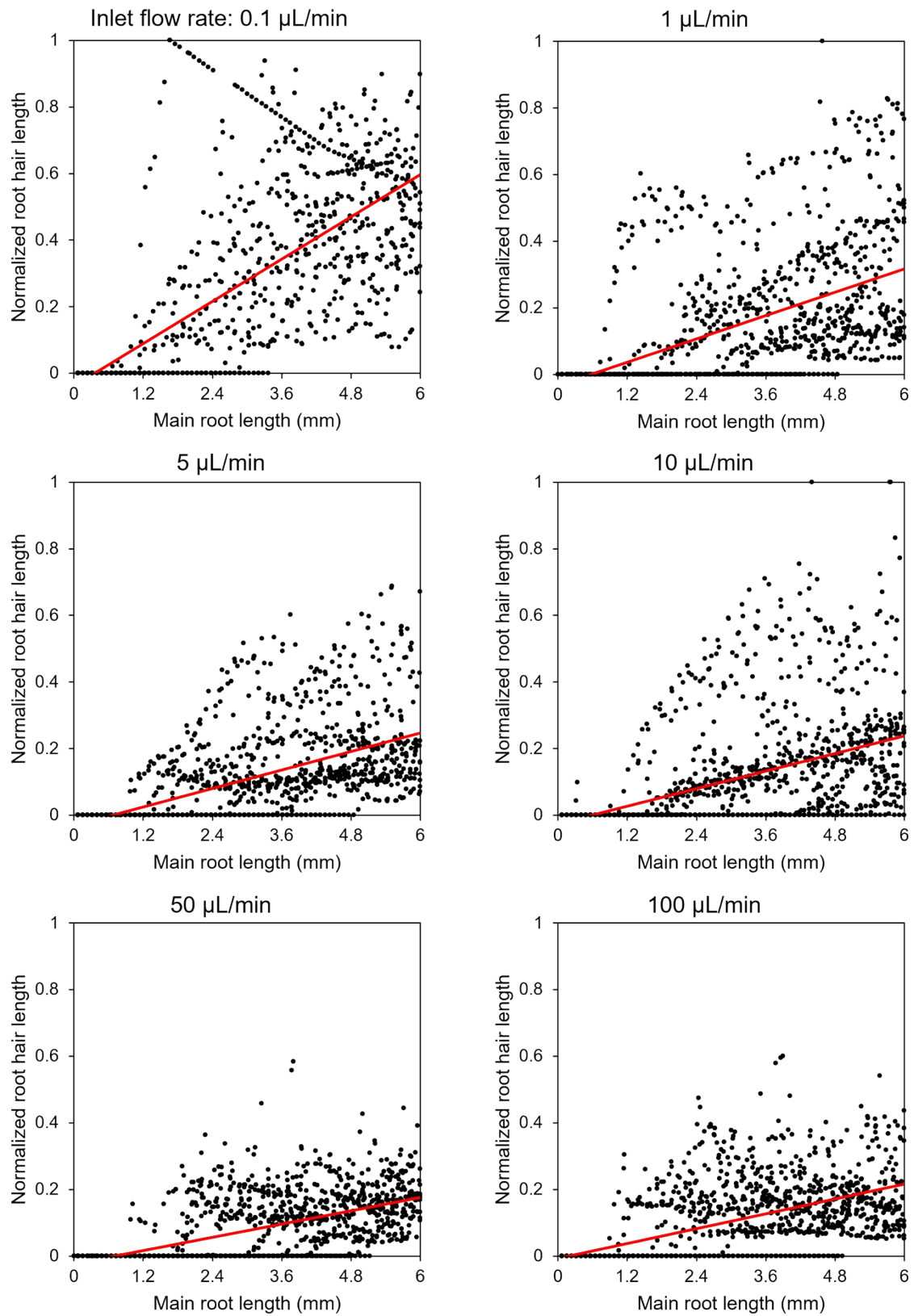


Fig. S5 Distribution of root hair length for (a) forward, (b) reverse, and (c) control groups within reference zone which is defined as 6 mm from root tip. Min-max normalization is used. Black dots and red lines represent root hair length data and fitted curves, respectively.

(b) Backward group

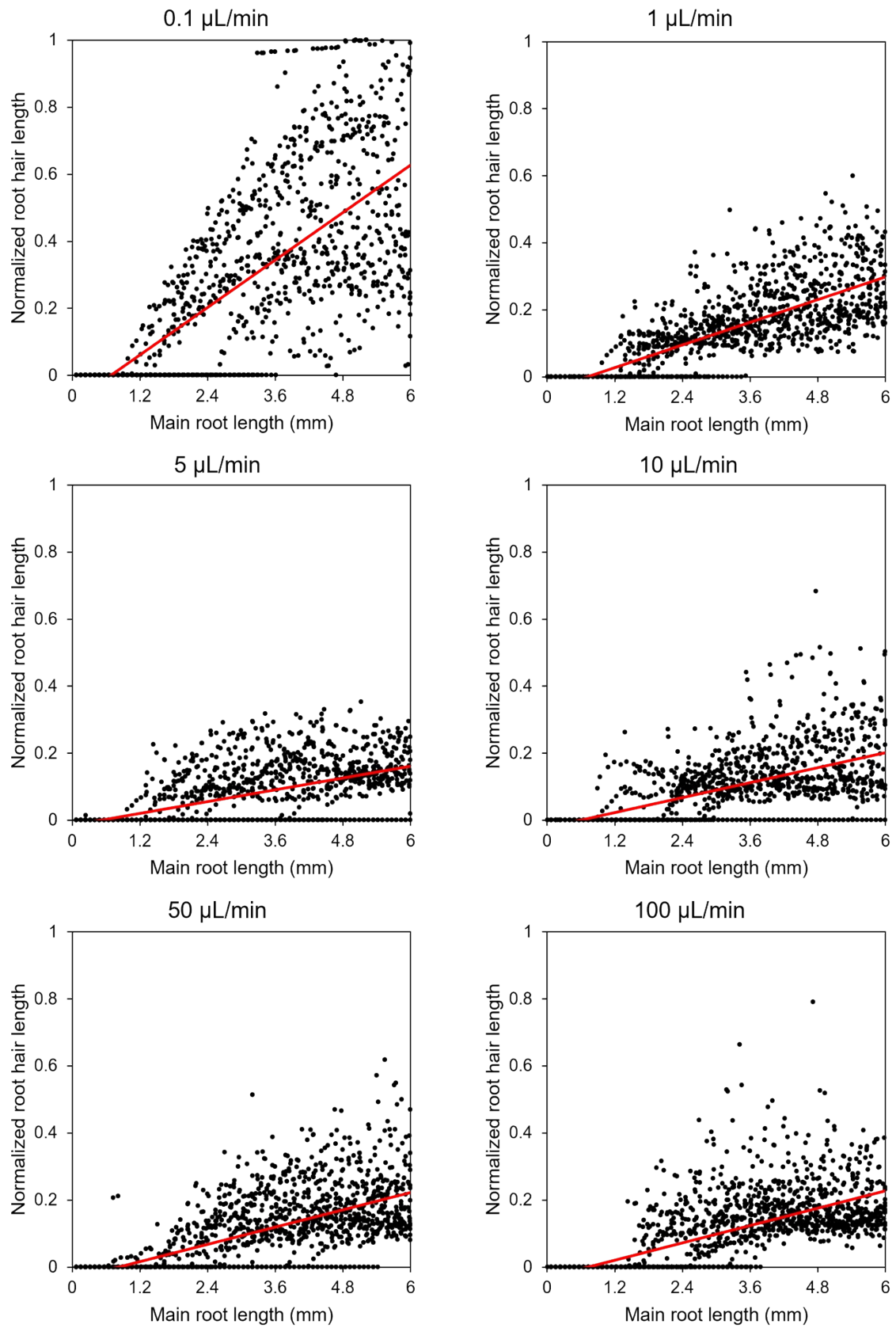


Fig.S5 (Continued)

(c)

Control group

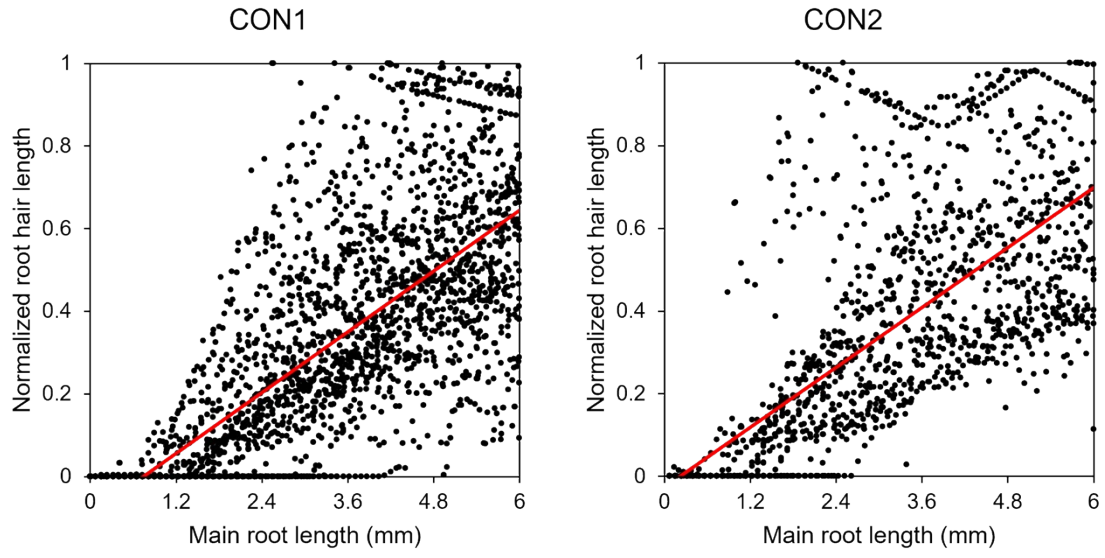


Fig.S5 (Continued)