Data Article

Data for quantitative research of mechanical properties of agar media with concentration gradient, and *Arabidopsis* root growth in these media

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**A R T I C L E   I N F O**

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**A B S T R A C T**

The mechanical properties of the plant culture medium affect plant growth and development significantly. The paper presents the data created for the published article entitled “Resistance from agar medium impacts the helical growth of *Arabidopsis* primary roots”. The data contains the real-time output forces of 0.5–1.2% agar media from Bluehill software, and the forces on the agar surfaces changing with the increase of displacement. Oscillatory rheological experiments were employed to verify the stiffness results of 0.5–1.2% agar media. Helix diameter and length of roots grown in gradient agar media for Col-0 and DR5-GUS *Arabidopsis* are exhibited.

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Specifications Table

| Subject                          | Physics                        |
|---------------------------------|--------------------------------|
| Specific subject area           | Root biomechanics              |
| Type of data                    | Tables, figures                |
| How the data were acquired      | Mechanical properties of gradient agar media were measured by Electro PULS E1000 (Instron, USA. Load cell: ± 2 kN Dynacell mounted to base) and Rotational rheometer (Haake MARS, Schwerte, Germany); average length and average helix diameter of 7-day-old roots for Col-0 and DR5-GUS Arabidopsis in these media were measured by microscope photograph and image J [1]. |
| Data format                     | Raw, analyzed                  |
| Parameters for data collection  | Under the conditions of 23 °C and 50% humidity, uniaxial compression experiment was performed on Electron Puls E1000 machine using Console Bulehill 3 software, and began when the load force touch the sample top area and reached 0.001 N. Loading rate was 1 mm/min. Finish the test when cross-head displacement reached 1.5 mm. Under the same condition, rheological properties of agar media were measured by a rotational rheometer, using 20 mm parallel plates at constant frequency (0.1 Hz) and strain (0.2%). |
| Description of data collection  | The relationship between agar stiffness, agar concentration and root elongation were determined. |
| Data source location            | Chongqing, China               |
| Data accessibility              | Mendeley data: https://data.mendeley.com/datasets/ktbcwrsh3r/2 |
| Related research article        | Y. Jie, W. Bochu, Z. Yong, H. Shieli, Resistance from agar medium impacts the helical growth of Arabidopsis primary roots, Journal of the mechanical behavior of biomedical materials 85 (2018) 43–50. doi:10.1016/j.jmbbm.2018.05.018 |

Value of the Data

- This data provide basic reference in determining optimal growing circumstances when cultivating Arabidopsis or other plants.
- The data presents information for investigating root growth, buckling and interaction with medium resistance [2].
- Researchers will benefit from the data in investigating the effects of agar rheology on growing plants [3].
- The incorporation of agar in growth medium could be designed in quantitative way and the results of root-gel interaction could be analyzed by physical method.
- To understand the influence of agar stiffness on plant growth in depth, the assessment of mechanical properties of agar made publicly available to make improvement for experiments.

1. Data Description

The data reported herein contains Loading Force-Displacement Curve for 0.5–1.2% agar media from uniaxial compression test (Fig. 1) and the relationship between agar concentration and moduli (Complex modulus and Elastica modulus) (Table 1). Data of root length (Table 2) and diameter of root helix (Table 3) in each agar media were presented when Col-0 and DR5-GUS Arabidopsis grow in agar media on the 7th day. Among the range from 0.5% to 1.2% agar media, no significant difference was found in both dimensions of the helical root and root length between Ecotype Columbia (Col-0) and DR5-GUS seeds (t-test, P > 0.05) (Fig. 2). The raw data associated with Fig. 2 were exhibited in Table 2 and Table 3.
Fig. 1. Loading Force-Displacement Curve for 0.5–1.2% agar media from uniaxial compression test. Rectangle samples (length = 40 mm, width = 20 mm, height = 12 mm), area = 800 mm$^2$. Common standard tests were used to determine the deformational displacement and Young’s modulus. The experiments were repeated more than three times for each agar concentration and similar results to those shown were observed.

Table 1
The relationship between agar concentration and moduli (Complex modulus and Elastica modulus). Oscillatory rheological experiments for the effect of agar on the medium rheology were at constant frequency (0.1 Hz) and strain (0.2%).

| Concentration of agar (%) | Temperature (°C) | Frequency | Complex Modulus (Pa) | Elastic Modulus (Pa) |
|---------------------------|------------------|-----------|----------------------|----------------------|
| 0.5                       | 23               | 0.5       | 15025                | 15166                |
| 0.6                       | 23               | 0.5       | 17748                | 17257                |
| 0.7                       | 23               | 0.5       | 22300                | 22389                |
| 0.8                       | 23               | 0.5       | 21824                | 20997                |
| 0.9                       | 23               | 0.5       | 25101                | 25143                |
| 1.0                       | 23               | 0.5       | 27209                | 27412                |
| 1.1                       | 23               | 0.5       | 39867                | 40054                |
| 1.2                       | 23               | 0.5       | 39188                | 39132                |
Table 2
Testing dataset with two genotypes of *Arabidopsis* roots. Length of 7-day-old primary roots of Col-0 and DR5-GUS in agar media with concentration of 0.5–1.2%. This dataset is connected with Fig. 2. a. Col-0 and DR5-GUS comparison in 0.5–1.2% agar media.

| Concentration of agar (%) | 0.5   | 0.6   | 0.7   | 0.8   | 0.9   | 1.0   | 1.1   | 1.2   |
|---------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Root length in **Col-0** (mm) |       |       |       |       |       |       |       |       |
| 0.5%                       | 14.322| 12.297| 11.234| 14.304| 10.802| 13.484| 13.103| 16.764|
| 0.6%                       | 9.962 | 11.333| 14.709| 13.861| 11.311| 12.542| 12.192| 14.879|
| 0.7%                       | 10.267| 12.53  | 13.679| 17.18  | 10.426| 12.961| 11.263| 17.738|
| 0.8%                       | 13.267| 8.307 | 15.276| 16.487| 17.754| 10.173| 11.864| 17.507|
| 0.9%                       | 10.96 | 10.926| 12.294| 14.288| 10.201| 12.192| 16.724| 24.478|
| 1.0%                       | 10.18 | 12.21 | 14.759| 14.861| 11.786| 12.612| 13.103| 16.764|
| 1.1%                       | 11.16 | 12.29 | 13.679| 17.022| 11.121| 10.173| 12.192| 14.879|
| 1.2%                       | 10.278| 11.333| 15.216| 14.121| 10.456| 12.255| 11.263| 17.738|
| Root length in **DR5-GUS** (mm) |       |       |       |       |       |       |       |       |
| 0.5%                       | 14.212| 12.53 | 11.294| 15.304| 12.213| 13.179| 11.864| 18.507|
| 0.6%                       | 10.119| 10.307| 11.294| 15.861| 10.802| 13.525| 13.724| 18.278|
| 0.7%                       | 10.28 | 10.93 | 12.287| 17.18  | 11.311| 10.173| 12.119| 19.049|
| 0.8%                       | 13.467| 10.322| 13.689| 16.887| 10.426| 13.879| 13.103| 17.738|
| 0.9%                       | 9.96  | 11.451| 12.255| 14.288| 12.754| 12.525| 12.192| 17.507|
| 1.0%                       | 10.57 | 8.406 | 13.879| 14.861| 10.201| 10.173| 11.263| 18.278|
| 1.1%                       | 13.127| 12.296| 12.525| 16.217| 10.936| 12.349| 11.864| 20.325|
| 1.2%                       | 14.12 | 12.429| 11.234| 16.304| 11.567| 12.541| 13.103| 19.738|
| Root length in **Col-0** (mm) |       |       |       |       |       |       |       |       |
| 0.5%                       | 11.221| 8.707 | 15.171| 16.487| 13.426| 12.525| 11.864| 24.121|
| 0.6%                       | 13.19 | 11.926| 13.445| 14.611| 16.754| 12.173| 12.724| 16.241|
| 0.7%                       | 12.17 | 11.035| 11.834| 13.861| 10.601| 11.795| 12.992| 16.984|
| 0.8%                       | 13.19 | 11.219| 14.709| 15.6604| 11.905| 12.112| 13.875| 18.615|
| 0.9%                       | 10.113| 12.011| 13.679| 14.318| 11.802| 13.879| 12.119| 18.278|
| 1.0%                       | 12.712| 12.197| 15.176| 15.821| 11.511| 12.525| 13.103| 20.325|
| 1.1%                       | 13.129| 11.353| 11.334| 15.324| 12.426| 10.173| 12.192| 17.738|
| 1.2%                       | 14.222| 12.53 | 14.609| 13.927| 11.511| 10.173| 11.263| 17.507|
| Root length in **DR5-GUS** (mm) |       |       |       |       |       |       |       |       |
| 0.5%                       | 13.946| 11.107| 13.679| 14.288| 10.426| 11.595| 11.864| 18.178|
| 0.6%                       | 13.497| 10.926| 15.078| 13.861| 16.798| 12.231| -      | 24.121|
| 0.7%                       | 12.866| 11.211| 13.453| 13.866| 11.811| 13.171| -      | 18.258|

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### Table 3
Testing dataset with two genotypes of *Arabidopsis* roots with helical growth pattern. Helix diameter of 7-day-old primary roots of Col-0 and DR5-GUS in agar media with concentration of 0.5–0.9%.

| Concentration of agar (%) | 0.5  | 0.6  | 0.7  | 0.8  | 0.9  |
|---------------------------|------|------|------|------|------|
| **Diameter of root helix in Col-0 (mm)** | 0.565 | 0.477 | 0.417 | 0.269 | 0.385 |
|                           | 0.465 | 0.438 | 0.312 | 0.277 | 0.28  |
|                           | 0.472 | 0.544 | 0.469 | 0.249 | 0.275 |
|                           | 0.516 | 0.4   | 0.573 | 0.326 | 0.165 |
|                           | 0.612 | 0.502 | 0.573 | 0.269 | 0.385 |
|                           | 0.548 | 0.635 | 0.472 | 0.277 | 0.38  |
|                           | 0.565 | 0.482 | 0.417 | 0.249 | 0.291 |
|                           | 0.563 | 0.397 | 0.435 | 0.326 | 0.275 |
|                           | 0.469 | 0.453 | 0.424 | 0.326 | 0.165 |
|                           | 0.611 | 0.502 | 0.521 | 0.326 | 0.385 |
|                           | 0.469 | 0.404 | 0.415 | 0.269 | 0.385 |
|                           | 0.515 | 0.515 | 0.415 | 0.272 | 0.28  |
|                           | 0.513 | 0.452 | 0.427 | 0.249 | 0.275 |
|                           | 0.518 | 0.343 | 0.443 | 0.226 | 0.165 |
|                           | 0.516 | 0.441 | 0.417 | 0.269 | 0.385 |
|                           | 0.612 | 0.414 | 0.431 | 0.275 | 0.38  |
|                           | 0.548 | 0.398 | 0.415 | 0.229 | 0.291 |
|                           | 0.565 | 0.462 | 0.412 | 0.326 | 0.275 |
|                           | 0.515 | 0.441 | 0.417 | 0.315 | 0.165 |
|                           | 0.513 | 0.446 | 0.437 | 0.281 | 0.385 |
| **Diameter of root helix in DR5-GUS (mm)** | 0.565 | 0.477 | 0.417 | 0.269 | 0.315 |
|                           | 0.469 | 0.438 | 0.312 | 0.277 | 0.28  |
|                           | 0.472 | 0.544 | 0.469 | 0.249 | 0.275 |
|                           | 0.556 | 0.523 | 0.573 | 0.326 | 0.165 |
|                           | 0.612 | 0.502 | 0.573 | 0.269 | 0.324 |
|                           | 0.548 | 0.635 | 0.472 | 0.357 | 0.385 |
|                           | 0.565 | 0.482 | 0.417 | 0.249 | 0.253 |
|                           | 0.469 | 0.397 | 0.417 | 0.326 | 0.271 |
|                           | 0.611 | 0.453 | 0.417 | 0.269 | 0.165 |
|                           | 0.469 | 0.502 | 0.332 | 0.277 | 0.367 |
|                           | 0.515 | 0.404 | 0.569 | 0.249 | 0.38  |
|                           | 0.523 | 0.59  | 0.353 | 0.334 | 0.271 |
|                           | 0.518 | 0.452 | 0.573 | 0.322 | 0.265 |
|                           | 0.546 | 0.343 | 0.472 | 0.305 | 0.175 |
|                           | 0.612 | 0.441 | 0.412 | 0.269 | 0.385 |
|                           | 0.551 | 0.454 | 0.435 | 0.272 | 0.375 |
|                           | 0.565 | 0.398 | 0.424 | 0.349 | 0.28  |
|                           | 0.615 | 0.395 | 0.551 | 0.326 | 0.275 |
|                           | 0.558 | 0.441 | 0.515 | 0.269 | 0.165 |
|                           | 0.578 | 0.502 | 0.415 | 0.275 | 0.294 |

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### 2. Experimental Design, Materials and Methods

#### 2.1. Agar Medium Preparation

The plant growth medium consisted of $0.5 \times$ Murashige, Skoog basal salts with Gamborg’s B5 vitamins (Sigma M-0404), 1.5% sucrose and 0.5–1.2% agar, and then was adjusted to pH 5.8 with KOH. The agar media were cast into rectangles (length = 40 mm, width = 20 mm, height = 12 mm) for compression test.

Homogeneous agar media with a series of concentration from 0.5% to 1.2% were poured into the petri dishes (Diameter = 9 cm, glass) with thickness of 2 mm [4]. A puncher with 2 cm diameter was pushed vertically into the agar layer to make round agar for oscillatory test [3].
Fig. 2. Average length and average helix diameter of 7-day-old primary roots of Col-0 and DR5-GUS in agar media. a. Col-0 and DR5-GUS comparison in 0.5–1.2% agar media. b. Col-0 and DR5-GUS comparison in 0.5–0.9% agar media. Col-0 and DR5-GUS comparison exhibited no significant difference (t-test, \( P > 0.05 \)).

2.2. Uniaxial Compression Test and Oscillatory Test

Under the conditions of 23 °C and 50% humidity, axial compression tests were performed on Electro PULS E1000. Loading rate was set as 1 mm/min, and the test was finished when cross-head displacement reached 1.5 mm. The rheological properties were measured using a rotational rheometer [3,5].
2.3. Root Length and Helical Root Shape for Col-0 and DRS-GUS Comparison

*Arabidopsis thaliana* roots were growing in agar media with increasing concentration as indicated in reference [1]. Images of roots (n = 30) were captured in every culture condition. Thirty roots from each agar media were tested for root length and diameter of helix. For clear visualization of the root growth pattern in agar media, 7-day-old roots were observed under an Olympus microscope. Measurements of microscopy pictures were conducted by Image J software.

**Ethics Statement**

This work didn’t involves the use of human subjects. The manuscript adheres to Ethics in publishing standard.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

**Data Availability**

Data for quantitative research of mechanical properties of agar media with concentration gradient, and *Arabidopsis* root growth in these media (Original data) (Mendeley Data).

**CRediT Author Statement**

**Yong Zhou:** Funding acquisition, Investigation, Methodology, Writing – original draft; **Meifeng Chi:** Resources, Software, Supervision, Validation, Writing – review & editing; **Haoyang Xiong:** Resources, Software, Validation; **Jie Yan:** Conceptualization, Data curation, Formal analysis, Writing – review & editing.

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