**Method details for GPT-framework-based model**

We used Growing Polarized Tissue (GPT) framework (Kennaway et al., 2011) rev. 6022 running on MATLAB R2019b to build leaf and floral primordium surface models. This framework treats plant tissue as a continuous sheet of material with two surfaces and a thickness, termed the canvas. The growth of the canvas is determined by three interacting networks: (1) the Gene Regulatory Network (GRN), which controls the activity of regional identity or signaling factors; (2) the Polariser Regulatory Network (PRN), which controls generation and removal of the diffusible signaling factor POLARISER (POL), whose gradient defines local polarity; (3) the Growth Rate Regulatory Network (KRN), which determines how identity or signaling factors influence specified growth rates parallel to (**k***par*) and perpendicular to (**k***per*) local polarity.

1. **Generation of the initial Mesh**

The initial Mesh is a circle with a diameter of 2 mm in the plane of the x-axis and y-axis, and the Mesh is set to bowl shape with an amplitude of -0.1 in the z coordinate. Circum number and Rings number of the Mesh are 120 and 30 respectively.

The area of primordium is defined by factor V\_PRIMORDIUM using the following function:

v\_primordium\_p((m.nodes(:,1) > 0.4) & (sqrt(m.nodes(:,1).^2 + m.nodes(:,2).^2) <= 0.85)) = 1,

which generates a closed graph made of a straight line and a segment of an arc. Primordium is further divided into different domains depending on situation. Leaf primordium is divided by the corresponding identity factors into three domains: adaxial domain (ID\_AD), middle domain (ID\_MID) and abaxial domain (ID\_AB), while floral primordium is divided into two domains: adaxial domain (ID\_AD) and abaxial domain (ID\_AB) by corresponding identity factors with expression areas different from those of leaf primordium.

1. **PRN**

GPT framework requires a polarity field to distinguish between growth parallel to, **k***par*, and perpendicular to, **k***per*, the polarity field direction. Polarity field can represent the main orientation of cell growth because that **k***par* is generally set to be larger than **k***per* in our model, therefore the direction of polarity field is defined according to the GAD results in Figure S2.

This polarity field is based on the local concentration gradient of a signaling factor, POLARISER (POL). POL is generated at the source defined by ID\_ORG\_PLUS and removed at the sink defined by ID\_ORG\_MINUS or ID\_ORG\_NEG. The values of POL in ID\_ORG\_PLUS and ID\_ORG\_MINUS are frozen to the canvas by the following functions:

m.morphogenclamp((id\_org\_plus\_p == 1), polariser\_i) = 1;

m.morphogenclamp((id\_org\_minus\_p==1), polariser\_i) = 1.

The areas of ID\_ORG\_PLUS are both the edges of primordium areas in leaf and floral primordium models, while the areas of ID\_ORG\_MINUS are different. ID\_ORG\_MINUS in leaf primordium models is the midline of the middle domain, whereas ID\_ORG\_MINUS of floral primordium models is a circle of 0.02 radius located on the adaxial domain. In floral primordium models of transgenic plants, a second polarity sink point of POL on the abaxial domain is required. Therefore, we added ID\_ORG\_NEG, an identity factor expressing a circle of radius 0.02 on the abaxial domain, to define the second sink. The value of POL in ID\_ORG\_NEG is also frozen to the canvas by the following function:

m.morphogenclamp((id\_org\_neg\_p==1), polariser\_i) = 1.

Note that although this new POL sink point is required to modify the model, the altered growth rate play more critical role in shape change (Figure S4B).

1. **KRN**

The growth process of our models has two phases: SAM formation (time step 0-10) and primordium growth (after time step 10), and both phases ignore the increase in the thickness of the canvas, i.e. consider **k*nor*** = 0. In the SAM formation phase, the settings of all models are identical. The initial Mesh grows at a decreasing rate from the center to edge as defined by ID\_SAM, and eventually bulges in the middle to form an approximately hemispherical surface to mimic SAM structure.

The growth rate patterns in primordium growth phase after time step 10 vary in different models depending on real cell growth patterns. To make the change of growth rates among domains more continuous, an identity factor ID\_G expressing in the entire primordium area is used to define a background growth rate. We used two methods to set different growth rates of different domains: the first method used different identity factors (e.g. ID\_AD, ID\_MID and ID\_AB, etc.) of different domains to adjust relative growth rates of corresponding domains relative to the background growth rate, and the second method multiplied the background growth factor ID\_G with a function determined by domain positions. Besides, considering the boundary of SAM and primordium grows slowly, we defined identity factor ID\_INH to limit the growth of this area in models. In leaf primordium models, ID\_INH is only in the boundary of SAM and adaxial domain of the primordium, while in floral primordium models, ID\_INH is in the boundary of SAM and the whole primordium. Followings are the detailed growth rate settings of each model.

The primordium growth phase of normal leaf primordium model has three stages. In the first stage (time step 10-20), the middle domain had fastest growth rate (ID\_G=2.0, ID\_MID=1.0), followed by the abaxial domain (ID\_G=2.0, ID\_AB=-1.5), and then the adaxial domain (ID\_G=2.0, ID\_AD=-1.9); In the second and the third stages (time step 20-30 and time step 30-40), the growth rate rises gradually from adaxial primordium boundary to the abaxial primordium boundary by multiplying ID\_G with a position determining function. And the overall growth rate of the third stage (ID\_G=0.5) is lower than the second stage (ID\_G=1.2) according to the experimental results. The leaf primordium model for *REVpro:miPRS* plant has only one growth stage (time step 10-40). The growth rates of adaxial domain and the middle domain are the same (ID\_G=1.0, ID\_AD=ID\_MID=0) and greater than that of abaxial domain (ID\_G=1, ID\_AB=-0.5).

For the wild-type floral primordium model, the growth rate was consistently greater in the adaxial domain (ID\_G=0.5, ID\_AD=0.2) than in the abaxial domain (ID\_G=0.5, ID\_AB=0.1). We also modelled the shape of floral primordium for transgenic plants *FILpro:PRS* and *LFYpro:amiR-TOR* respectively. For the former one, a higher abaxial growth rate (ID\_AB=1.5) multiplying a position determining function is used to generate the ectopic bulge on the abaxial domain. And the final shape of the latter one depends on the degree of abaxial ectopic growth rate. It displays a similar shape with the former one when the abaxial growth rate is much greater (ID\_AB=1.0, multiplying a position determining function) and turns out slightly flatten when the abaxial growth rate is relatively smaller (ID\_AB=0.4).

All factors used in our models and their areas and functions are summarized in Methods S1 (also at the end of this file), which also lists the values of key parameters related to the growth rate.

1. **Analysis of model robustness**

To test the robustness of 3D models, we varied the values of several critical parameters related to growth rate and then measured the deviation of specific indicators (Figure S4C-S4G). We may conclude that the five models are generally robust.

For normal leaf primordium model, we selected ID\_MID, ID\_AB, ID\_AD from the first stage and ID\_G from the second to test robustness. The indicator is angle α at time step 40 (Figure S4C). The deviations of angle α caused by the variation of ID\_MID and ID\_AB within tested range fluctuated around 1, and the deviations caused by ID\_AD and ID\_G varying within ±5% range were also not obvious (Figure S4C). We also analyzed factors ID\_AD and ID\_AB from *REVpro:miPRS* leaf primordium model, and the indicator was the ratio of width to thickness on the top view of the model results (Figure S4D). Although ID\_AD varying from -0.2 to 0.2 causes indicator decreasing gradually, this deviation is acceptable considering we cannot tell whether this variance range is much wider than the robustness interval (because we cannot calculate the variance ratio when the original value of ID\_AD is 0). And when ID\_AB varied over a range of ±20%, the indicator remained relatively stable (Figure S4D).

For normal floral primordium model, we tested the robustness of ID\_AD and ID\_AB with the same indicator as it for normal leaf primordium model, and they both performed stability over a wide range (±40%) (Figure S4E). We also analyzed the stability of ID\_AB for floral primordium model of *FILpro:PRS* plant and used the length of the ectopic abaxial bulge on the top view as an indicator. The variation of this parameter in the range of ±20% caused a large degree of fluctuation of the indicator (Figure S4F). The floral primordium model of *LFYpro:amiR-TOR* plant displays two distinct shapes depending on the value of ectopic abaxial growth. And considering the shape causing by a higher abaxial growth is similar to the shape of *FILpro:PRS* floral primordium model, we only tested the robustness of small value of ID\_AB (ID\_AB=0.4) with the ratio of width to thickness as the indicator. And the deviation of indicator is not significant when ID\_AB varied in the range of ±20% (Figure S4G).

**Methods S1. Parameter description and value for the GPT-framework-based models.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameter Description** | | | | | |
| **Name** | | | **Area** | | **Function** |
| V\_PRIMORDIUM | | | A closed graph made by a line and a segment of an arc in Mesh | | Define and display the area of primordium |
| V\_SAM | | | A circle with origin as the center and 0.9mm as the radius | | Display SAM area |
| ID\_SAM | | | A circle with origin as the center and 0.9mm as the radius | | Define the area of SAM; Define the growth rate in the SAM formation phase |
| ID\_AD | | | Adaxial domain of leaf and floral primordium models | | Define the area of adaxial domain; Define the relative growth rate of adaxial domain to adjust total growth rate |
| ID\_MID | | | Middle domain of leaf primordium models | | Define the area of middle domain; Define the relative growth rate of middle domain to adjust total growth rate |
| ID\_AB | | | Abaxial domain of leaf and floral primordium models | | Define the area of abaxial domain; Define the relative growth rate of abaxial domain to adjust total growth rate |
| ID\_G | | | Entire primordium area | | Define the background growth rate of entire primordium |
| ID\_ORG\_PLUS | | | Edge of the primordium area | | The source of POL |
| ID\_ORG\_MINUS | | | Midline of middle domain in leaf primordium models; A circle of radius 0.02 on the adaxial domain in floral primordium models | | The sink of POL |
| ID\_ORG\_NEG | | | A circle of radius 0.02 on the abaxial domain in floral primordium models of transgenic plants | | The sink of POL |
| ID\_INH | | | The boundary of adaxial leaf primordium and SAM; The boundary of entire primordium and SAM | | Inhibit the growth of boundary between primordium and SAM |
| ID\_NOPOLAR | | | Entire Mesh apart from the area of primordium | | Eliminate the POL diffusing out of the primordium area |
| F\_BOUNDARY | | | The edge of primordium area | | Help set ID\_ORG\_PLUS |
| F\_BORDER | | | Mesh area apart from the area of ID\_SAM | | Help fix t x, y and z vertices for the base to prevent base from moving up or down |
| F\_INHIBIT | | | The boundary of adaxial leaf primordium and SAM; The boundary of entire floral primordium and SAM | | Help set ID\_INH |
| F\_POLARITY | | | Midline of the middle domain in leaf primordium models | | Help set ID\_ORG\_MINUS in leaf primordium models |
| **Parameter Value** | | | | | |
| **Leaf primordium model of wild type plant** | | | | | |
| **Factor Name** | **Stage** | **Value** | | **Note** | |
| ID\_G | Stage 1 | 2 | |  | |
| Stage 2 | 1.2 | | Multiplying with a position determining function | |
| Stage 3 | 0.5 | | Multiplying with a position determining function | |
| ID\_AD | Stage 1 | -1.9 | |  | |
| ID\_MID | Stage 1 | 1 | |  | |
| ID\_AB | Stage 1 | -1.5 | |  | |
| ID\_INH | Stage 1 | -3 | |  | |
| Stage 2 | -2 | |  | |
| Stage 3 | -1 | |  | |
| **Leaf primordium model of *pREV::miPRS* transgenic plant** | | | | | |
| **Factor Name** | | **Value** | | **Note** | |
| ID\_G | | 1 | |  | |
| ID\_AD | | 0 | |  | |
| ID\_MID | | 0 | |  | |
| ID\_AB | | -0.5 | |  | |
| ID\_INH | | -3 | |  | |
| **Flower primordium model of wild type plant** | | | | | |
| **Factor Name** | | **Value** | | **Note** | |
| ID\_G | | 0.5 | |  | |
| ID\_AD | | 0.2 | |  | |
| ID\_AB | | 0.1 | |  | |
| ID\_INH | | -1.5 | |  | |
| **Flower primordium model of *pFIL::PRS* transgenic plant** | | | | | |
| **Factor Name** | | **Value** | | **Note** | |
| ID\_G | | 0.5 | |  | |
| ID\_AD | | 0.2 | |  | |
| ID\_AB | | 1.5 | | Multiplying with a position determining function | |
| ID\_INH | | -1.5 | |  | |
| **Flower primordium model of *pLFY::amiR-TOR* transgenic plant** | | | | | |
| **Factor Name** | | **Value** | | **Note** | |
| ID\_G | | 0.5 | |  | |
| ID\_AD | | 0.1 | |  | |
| ID\_AB | | 0.4 | | Flatten shape | |
| 1 | | Ectopic bulge on abaxial domain;  Multiplying with a position determining function | |
| ID\_INH | | -1 | |  | |