# Appendix C

This appendix presents how to use the *PlantVR* software. The *PlantVR* software is called the following icon.


**Figure C-1: The main program icon.**

The main program is shown as the following window. There are eight pages. First, the L-system page is used to create the physiology of plant. Second, the growth function page is used to set the growth function of each component, such as internode *I*, petiole *P*, apex *A*, leaf *L*, and flower *F*. Third, the component page is used to define the leaf and flower shape of plant. Fourth, the parameter page is used to adjust many parameters of plant shape and growing. Fifth, the animation page is used to set the

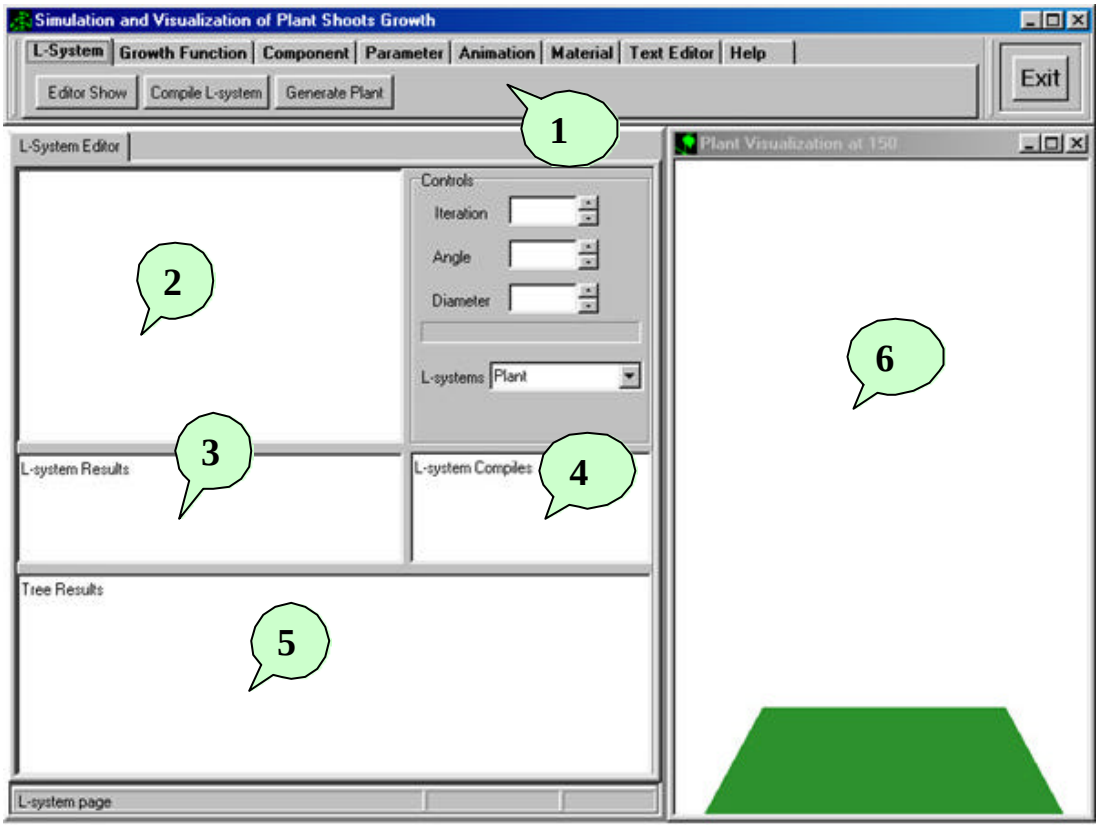


**Figure C-2: The main program.**

animated appearance and export the animation format to “GIF animation”, and the frame of development. Sixth, the material page is used to set the color of each component. Seventh, the text editor is used to store the L-system code. Finally, the help page is user manual.

The description of Figure C-2 has six parts. The first, it is the main menu of the software. The second, it is the L-system editor, the L-system code will be entered in this editor. The third, the L-system result will be shown after compiling the code, the plant prototype. The number of iteration, the angle, the diameter, the production rules, and the endprodution rules are interpreted and writing in the third block. The fourth, the compiled result of L-system is shown in this block. If there are any errors of L-system code, the error message will be shown in this block. The process will be stopped. The fifth, the L-system string will be shown in this block after press the button “Generate Plant” at the main menu. The sixth, the visualization will be shown as three-dimensional plant in this window.

The L-system code is entered in L-system editor page in Figure C-3. It is compiled for the L-system symbol string. The *Soybean* prototype in Chapter 4 will be used for an example model. The L-system is given below.

```
Soybean{
    Iterations=6
    Angle=45
    Diameter=1.5
    Axiom=I[-iL][+iL]A
    A=I[-P]I[+B]A
    P=IIII[\pL][/pL][-pL]
    B=IIII[\pL][/pL][+pL]
    ENDRULE
    B=IL
    P=IL
   A=IL
}
```

The *Soybean* prototype has six iteration, 45 degrees for the petiole angle, 1.5 centimeters for diameter of first internode, three production rules, and three endproduction rules.

## 1. The L-system page

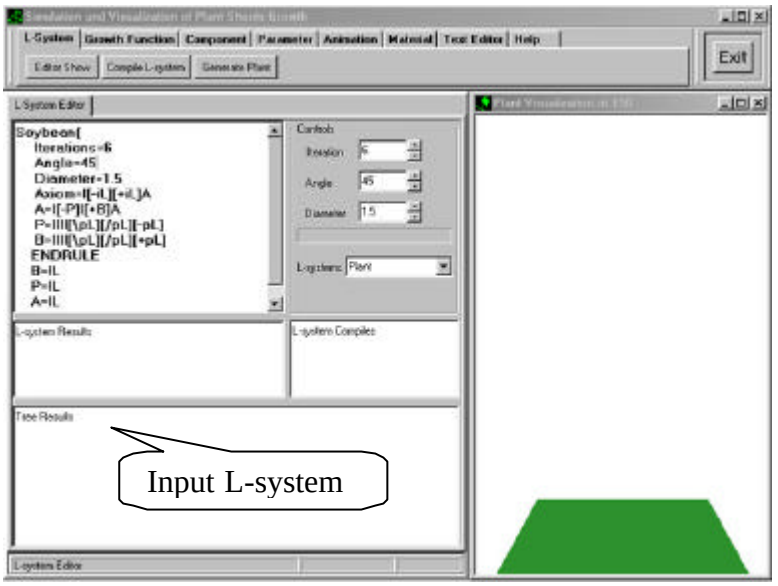


**Figure C-3: The L-system input.**

The generated plant is constructed by the following step:

1. Input L-system code in the L-system code editor and set the appropriated iteration, angle, and diameter
2. Select the “Compile L-system” button to compile the code and check the syntax
3. Select the “Generate Plant” button to interpret the L-system string to the plant physiology

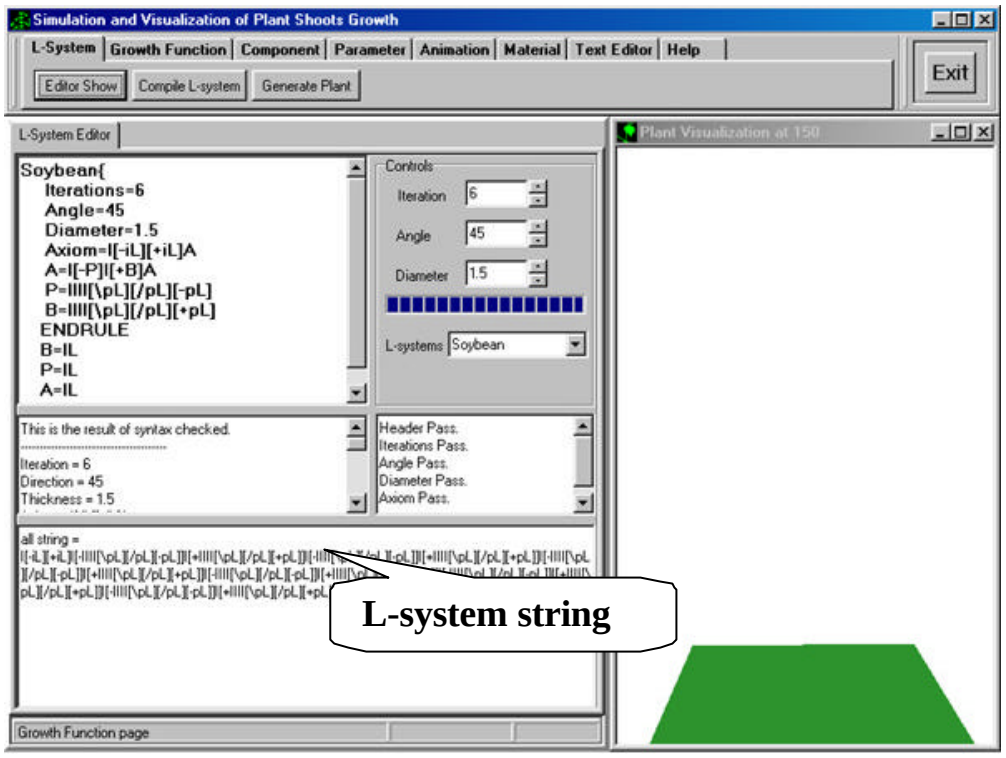


**Figure C-4: The result after generating plant.**

The final of three steps for creating plant model in L-system page is shown in Figure C-4. If there are any error in each step, the user will edit the L-system code and recompile and regenerate the plant.

## 2. The growth function page

The growth function page consists of the growth function of the internode, the petiole, the leaf length, the leaf width, the apex, and the flower for the symbol *I, i, P, p, L, A, F,* respectively. The growth function page is shown in Figure C-5. The growth function of each component is selected as follow the symbol of L-system

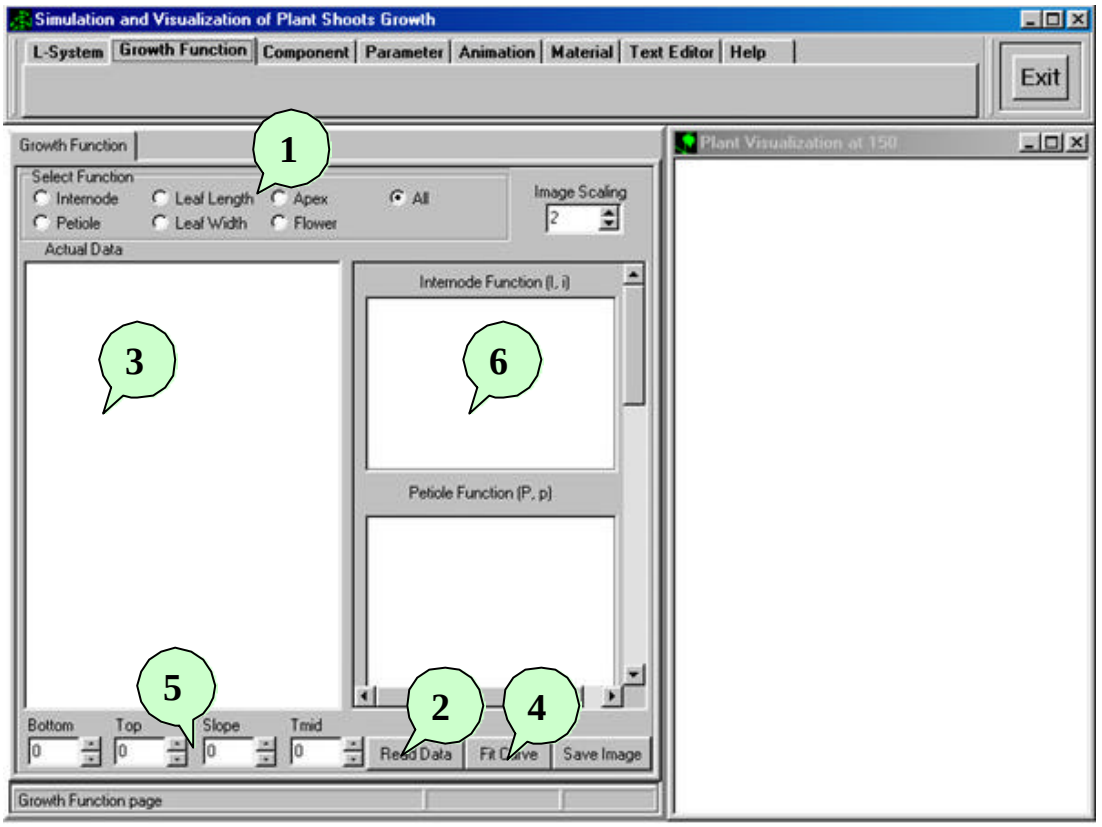


**Figure C-5: The growth function page.**

string in L-system page.

The step of growth function is described the following steps:

1. Select the function of symbol such as select the internode radio button for symbol *I* and *i*, the petiole button for symbol *P* and *p*, the leaf length for symbol *L*, the leaf width for symbol *L*, the apex for symbol *A*, the flower for symbol *F*, and all the button for every component.
2. Select the "Read data" button to open the data file, the data will be shown in the callout number three.
3. Select the "Fit Curve" button at callout number four to approximate the growth function of each component.
4. The four parameters of data will be shown at the callout number five. There are bottom, top, slope, and tmid value. Their meanings were described in Chapter 4.

5. The growth function of each component will be drawn in the callout number six

The internode component will be selected and open the data as Figure C-6. The data file of internode are shown in Figure C-7.

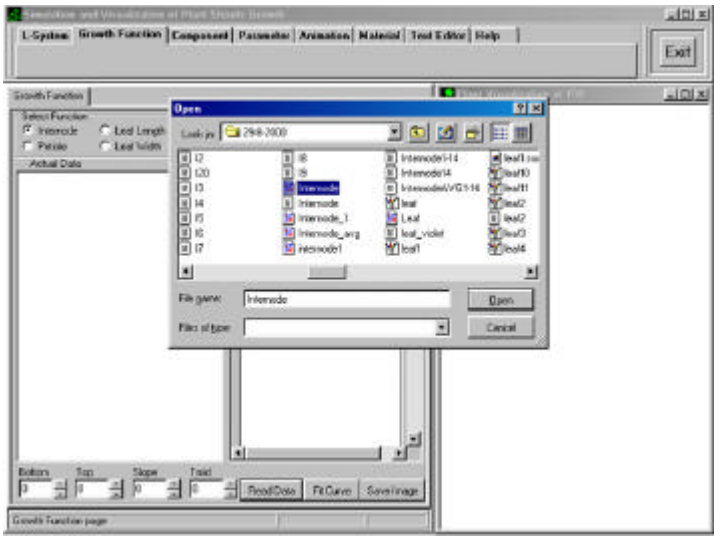


**Figure C-6: Open the data file.**

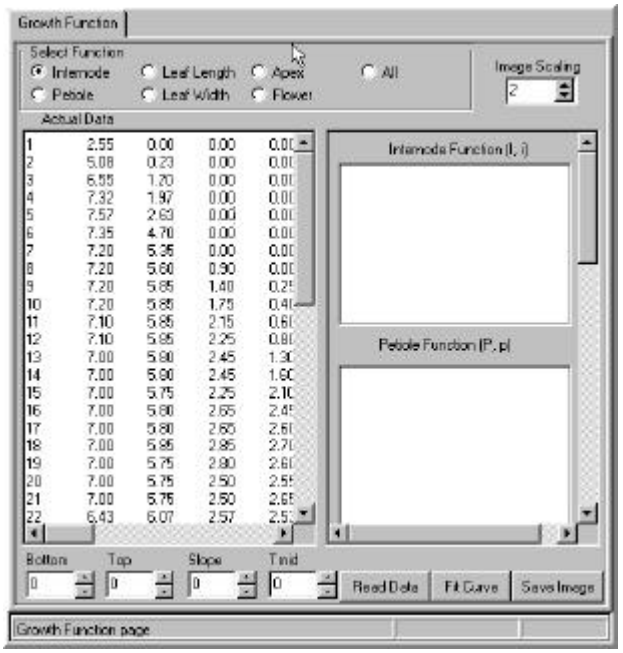


**Figure C-7: Internode data.**

The curve of internode growth function is shown in Figure C-8. The red line is the average of raw data, the blue line is the approximated growth function. The bottom, the top, the slope, and the tmid are 0.1275, 4.039, 0.65, 7.0, respectively.

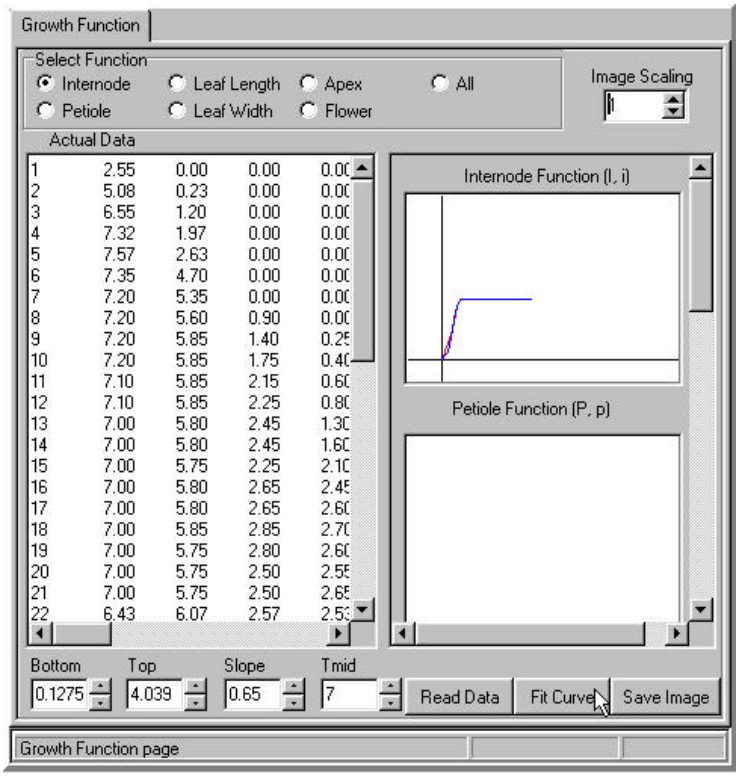


**Figure C-8: Internode growth function.**

The petiole data will be selected like the internode, that is, select the petiole radio button, and select the "Read data" button. The data file of petiole will be shown like Figure C-9. Then click the "Open" button to open the petiole data file.

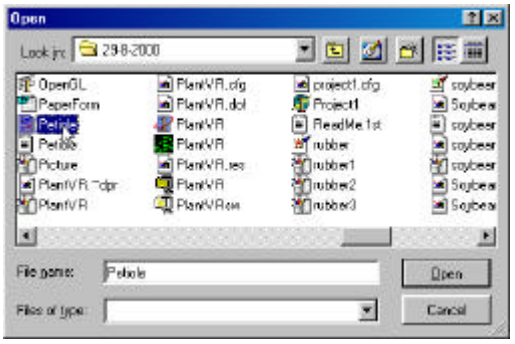


**Figure C-9: Open the petiole data file.**

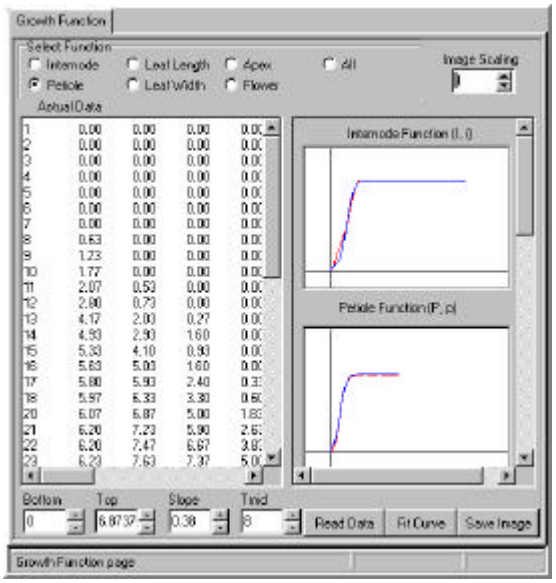


**Figure C-10: Petiole growth function.**

Then, click the "Fit Curve" button to approximate and draw the curve of petiole growth function in Figure C-10.

To open the leaf length data, click the "Read data" and select the leaf length data file and click "Open" button like Figure C-11, then click the "Fit curve" button to show the curve of growth function as Figure C-12.

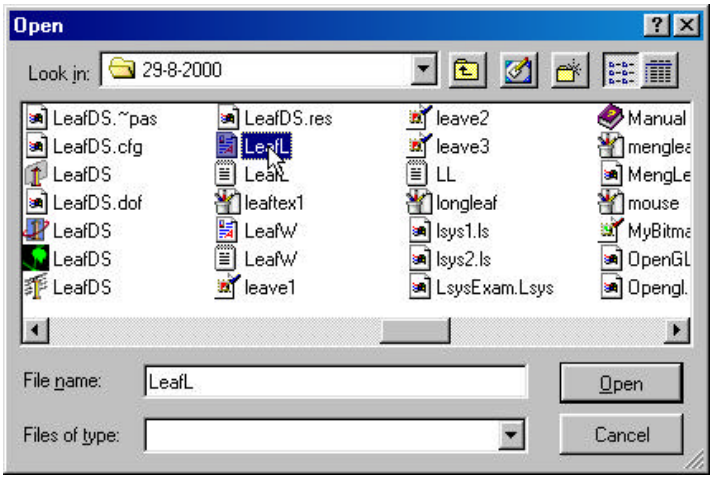


**Figure C-11: Open the length of leaf data.**

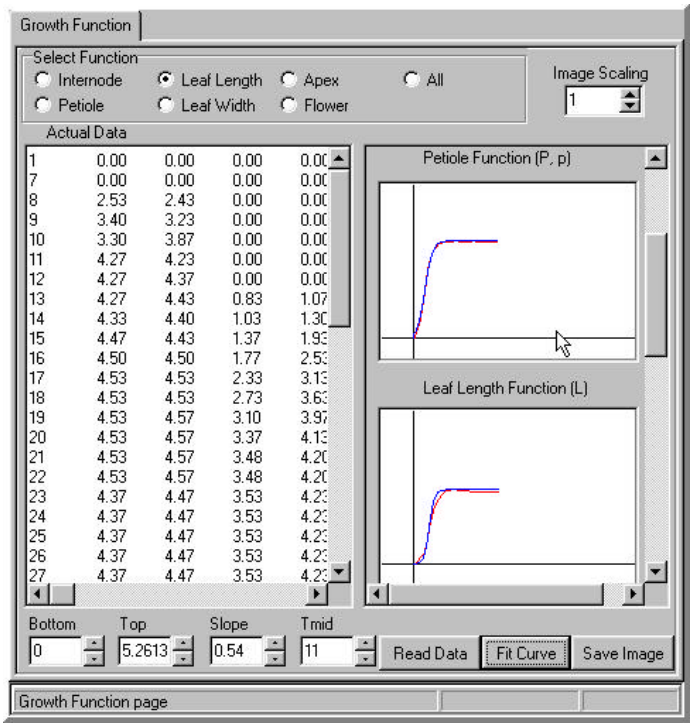


**Figure C-12: The leaf length growth function.**

In a similar way, click the “Read data” button to open the leaf width data and click “Open” button as Figure C-13, and click the “Fit Curve” button to fit the growth curve of leaf width as Figure C-14.

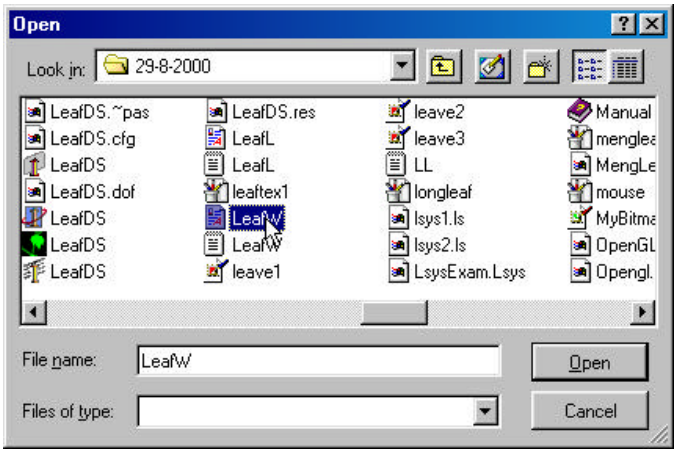


**Figure C-13: Open the width of leaf data.**

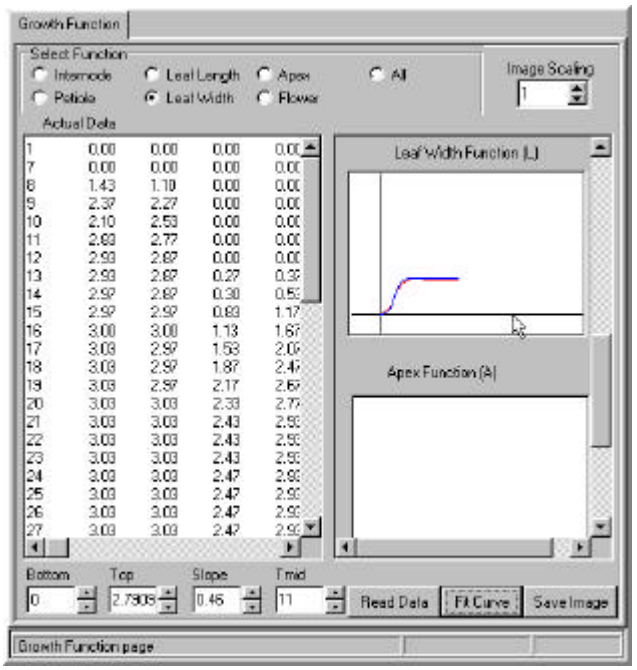


**Figure C-14: The leaf width growth function.**

The apex represents with the symbol *A*, therefore, we must select and set the growth function for apex growth function. Click the "Read data" button to open the data file, we assume that the apex growth curve as same as the internode function. Then click the internode file and fit curve, the result of apex growth function is shown in Figure C-15.

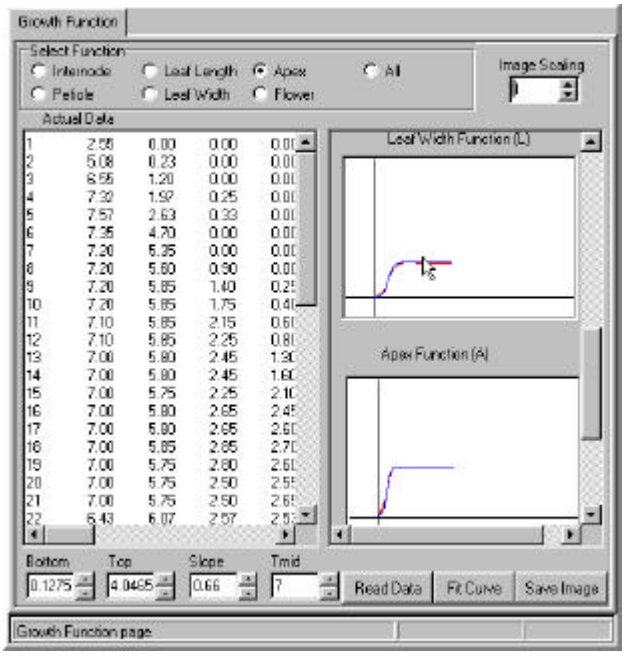


**Figure C-15: The apex growth function.**

All of growth function , internode, petiole, leaf length, leaf width, and apex are summarized in Figure C-16.

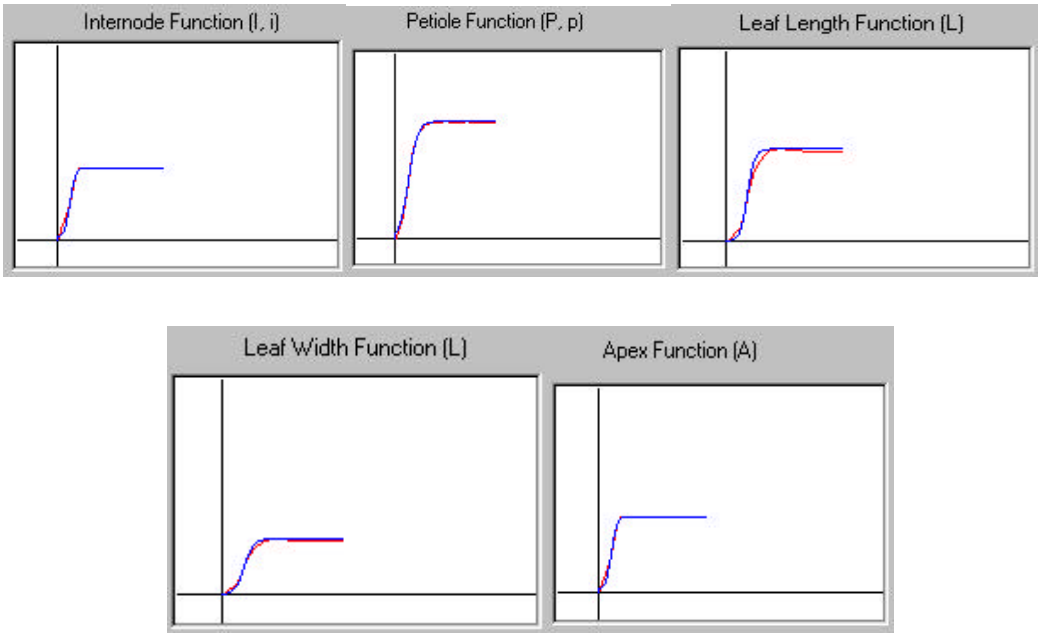


**Figure C-16: The growth function of internode, petiole, leaf length , leaf width, and apex function.**

## 3. The component page

The component page is used to define the shape of leaf and flower. To define the leaf and the flower component, the order of definition is shown in Figure C-17. First, Click “Open 3D Surface” to open the leaf and the flower library as Figure C-18. Second, click the radio button “Leaf Surface” to define the leaf surface. Third, select the leaf type at the combox box like Figure C-19 and the leaf shape will be shown in the callout number three like Figure C-20. If the letter *F* is appeared in the L-system string, we should define the flower shape. Fourth, click the radio button “Flower Surface” and select the flower type, the flower shape will display at the callout number five.

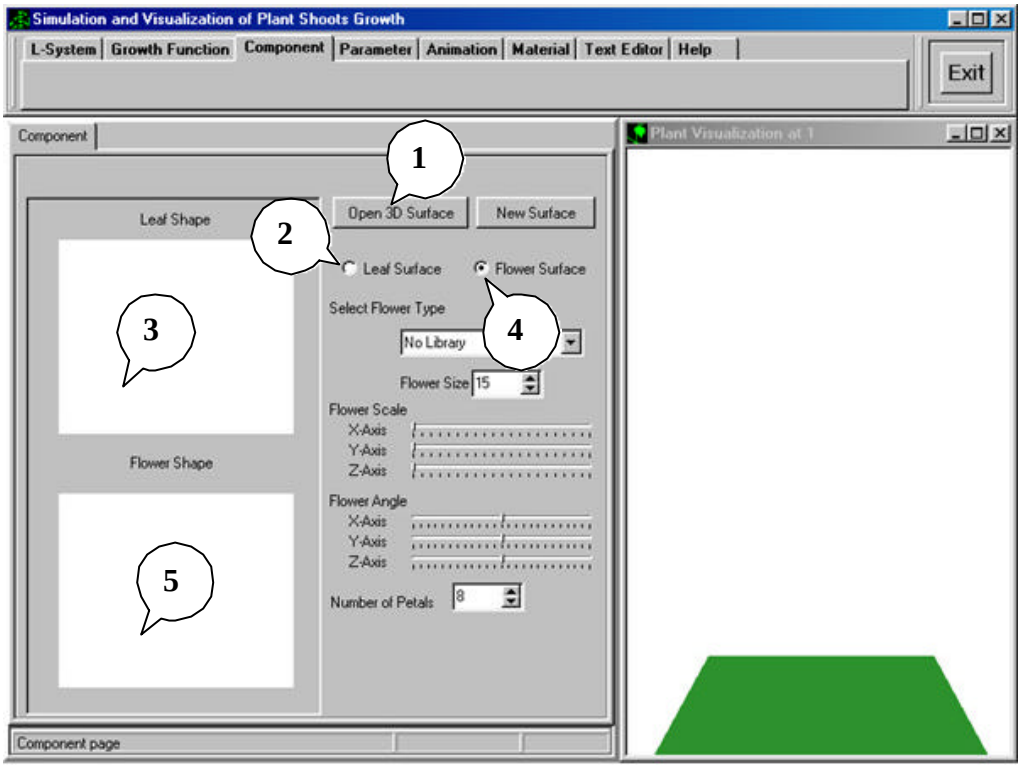


**Figure C-17: The component page.**

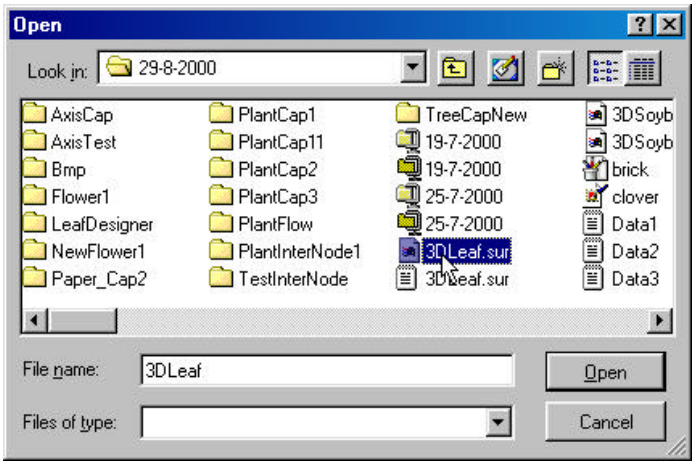


**Figure C-18: Open the leaf and flower library.**

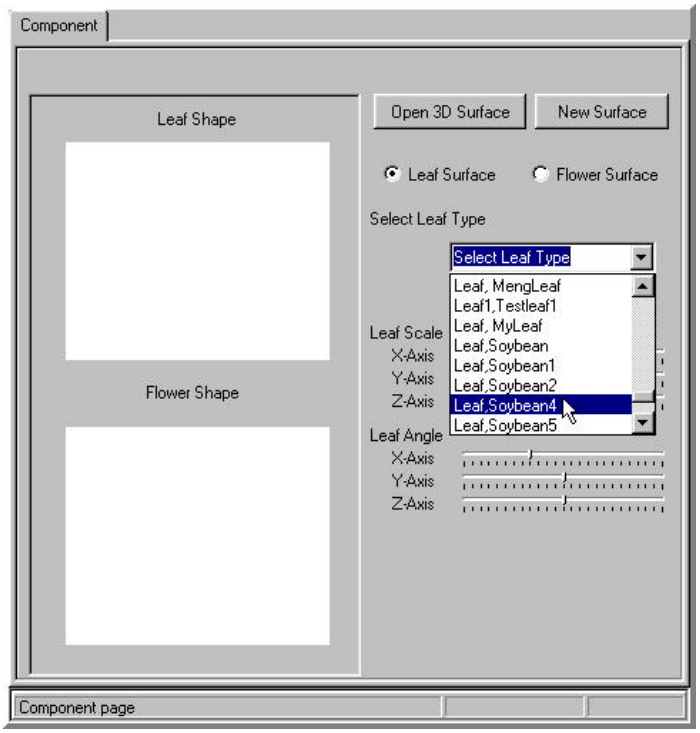


**Figure C-19: Select the soybean leaf.**

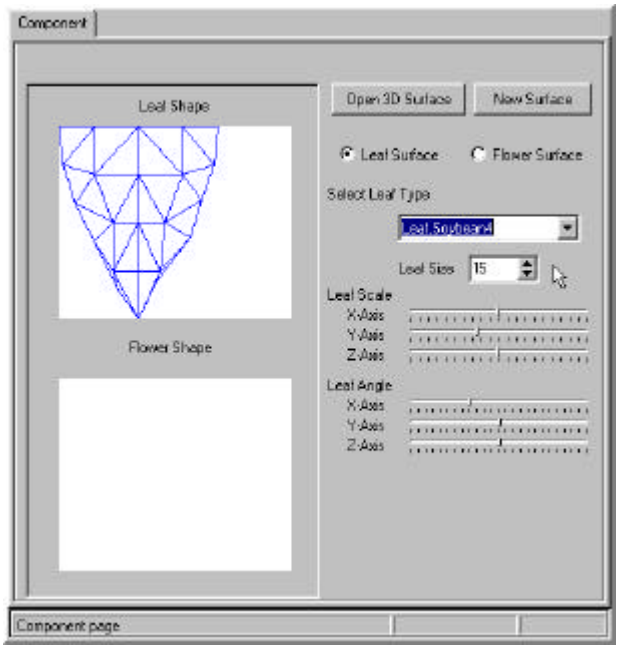


**Figure C-20: The part shape of soybean leaf.**

## 4. The parameter page

This page is used to set the plant shape and the plant growth parameter. The parameters are described as following.

1. The initial value of petiole angle is used to set the initial angle of branch and main stem.
2. Stem length is used to control the length of main stem.
3. Node diameter is used to set the diameter of internode and petiole.
4. Node Birth Rate is used to set the initial time of each component.
5. Petiole length is used to control the length of petiole.
6. Petiole bit angle is used to control the angle between the petiole and main stem.
7. Internode reduce is used to control the internode diameter.
8. Petiole reduce is used to control the petiole diameter.
9. Leaf reduce is used to control the leaf size.
10. Flower reduce is used to control the flower size.
11. Short internode ratio is used to control the length ratio between the short internode and the internode.

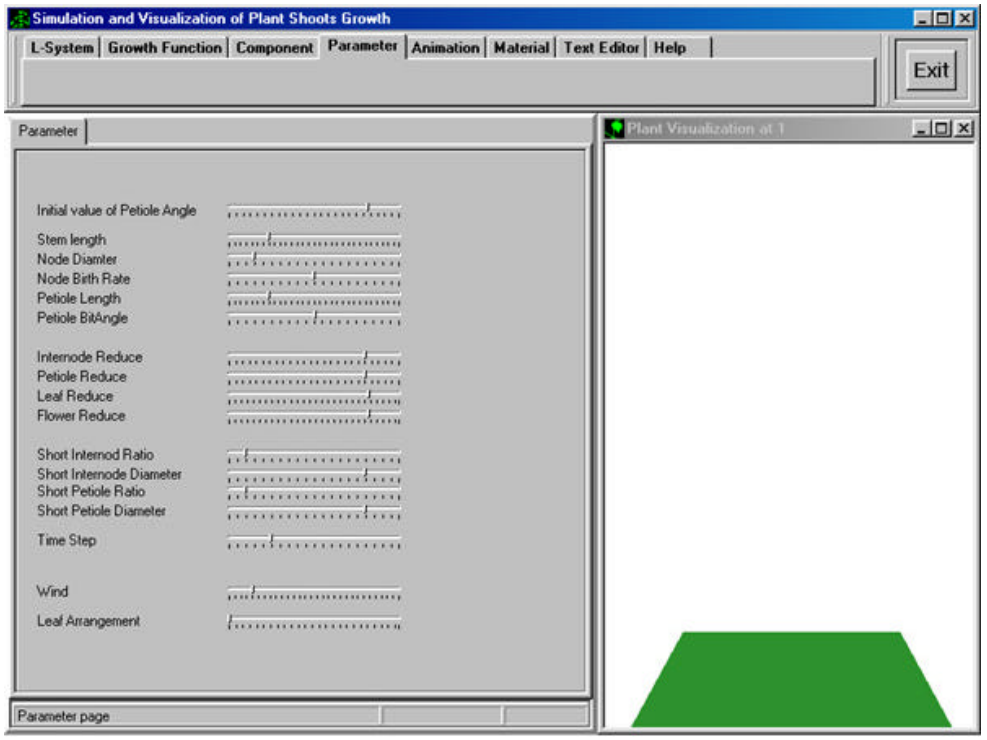


**Figure C-21: The parameter page.**

12. Short internode diameter is used to control the diameter ratio between the short internode and the internode.

13. Short petiole ratio is used to control the length ratio between the short petiole and the petiole.
14. Short petiole diameter is used to control the diameter ratio between the short petiole and the petile.
15. Time stem is used to set the increasing time step.
16. Wind is used to set the bit randomness angle of leaf.
17. Leaf arrangement is used to set the arrangement of leaf angle.

All parameter is shown in the parameter page as Figure C-21.

## 5. The animation page

The animation page is used to control the animation of plant such as the rotation, translation, zoom, velocity of animation, scaling, capture image. The animation page is shown in Figure C-22.

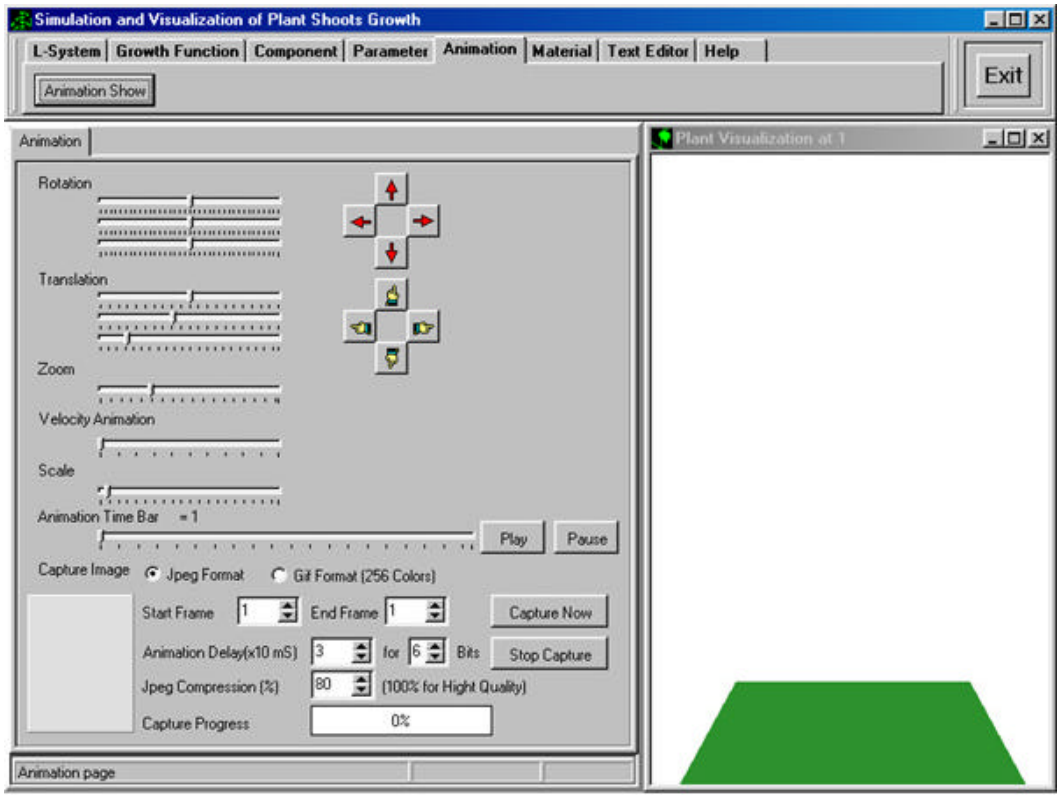


**Figure C-22: The animation page.**


**Figure C-23: The menu of animation page.**

To show the plant model, click “Animation Show” button as Figure C-23. The plant model is displayed in the plant Visualization windows as Figure C-24.

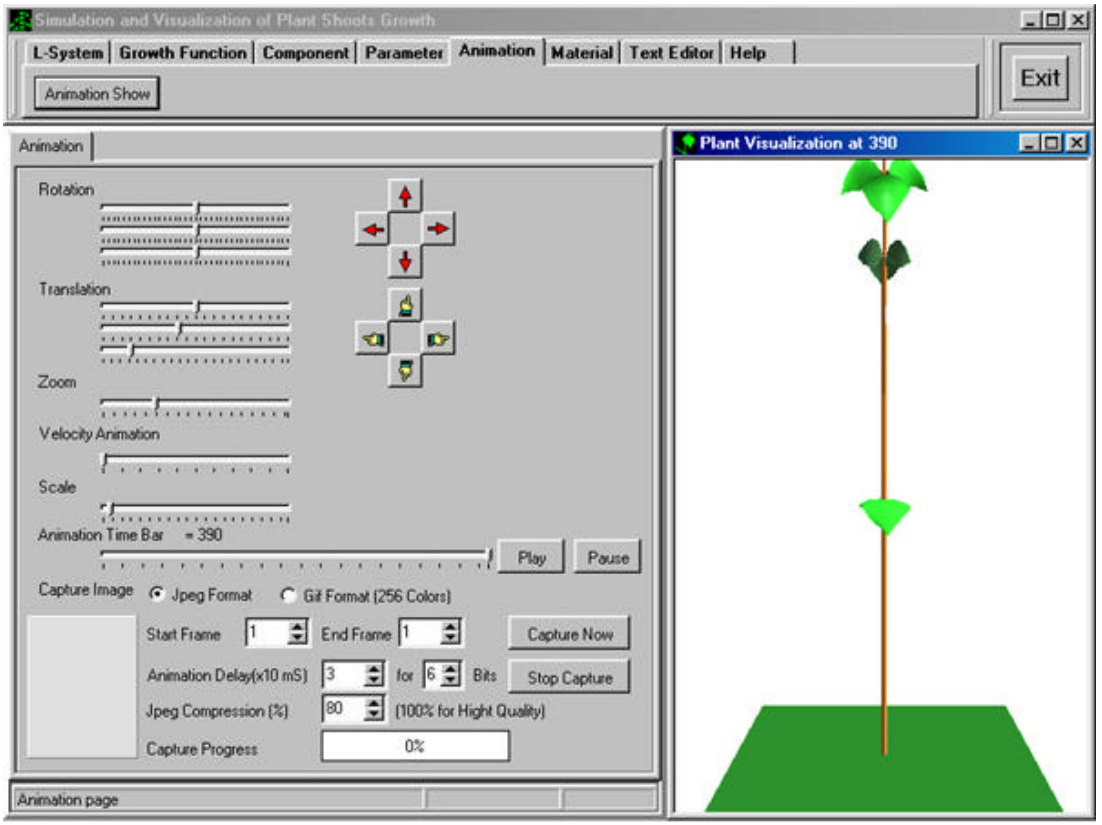


**Figure C-24: The first result of plant model.**

To reduce the plant main stem, click the stem length to reduce the value at the trackbar as Figure C-25. The plant model is displayed in real-time showing.

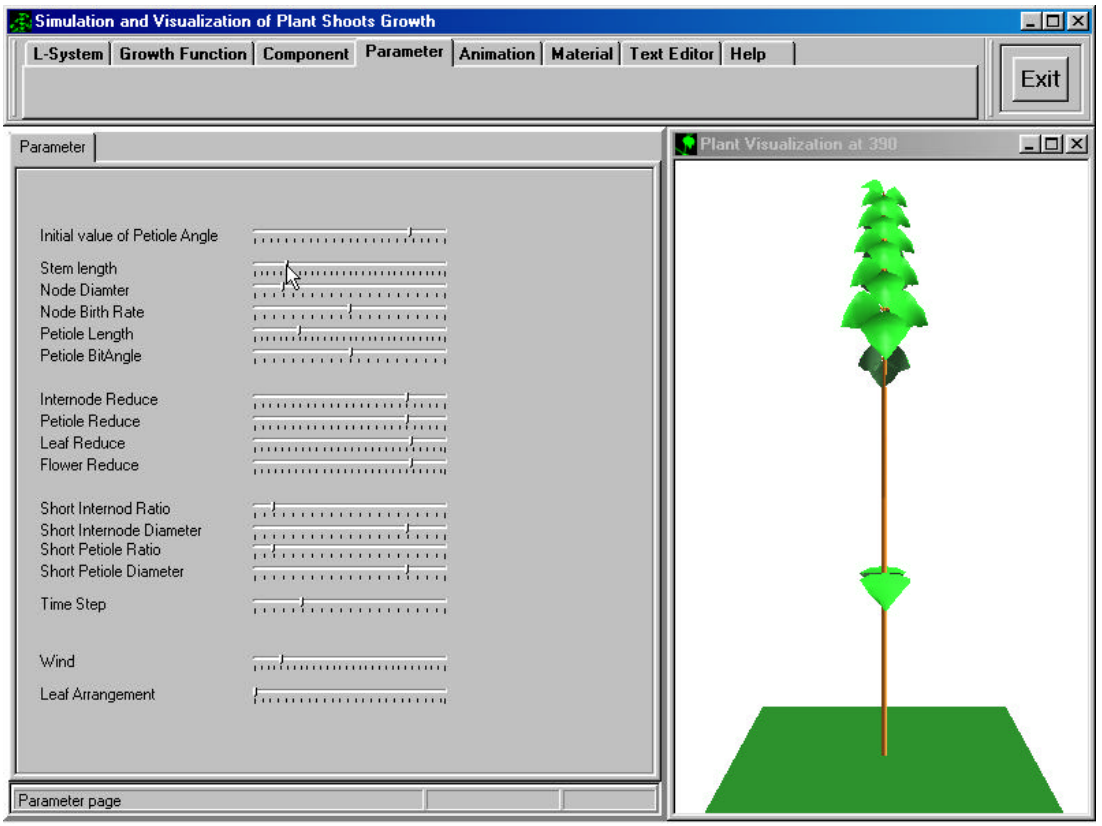


**Figure C-25: Set the length of main stem.**

To rotate the plant model, click the animation page, and click the second trackbar of rotation to rotate about Y-axis. The plant model is shown in Figure C-26.

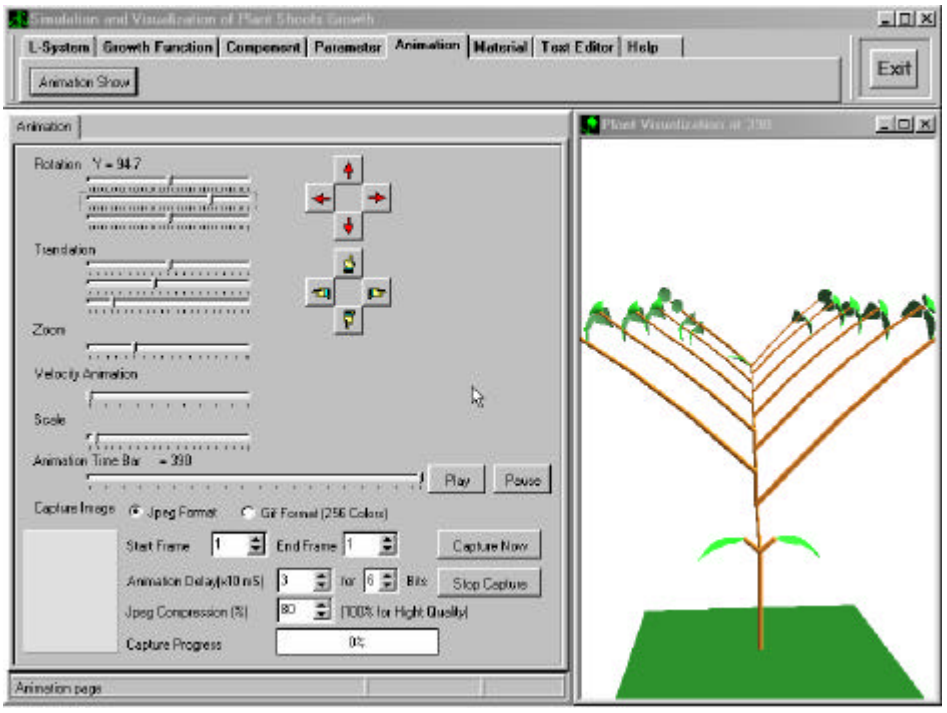


**Figure C-26: Adjust the rotation on Y-axis.**

To reduce the petiole length, click petiole length. The plant model is displayed as Figure C-27.

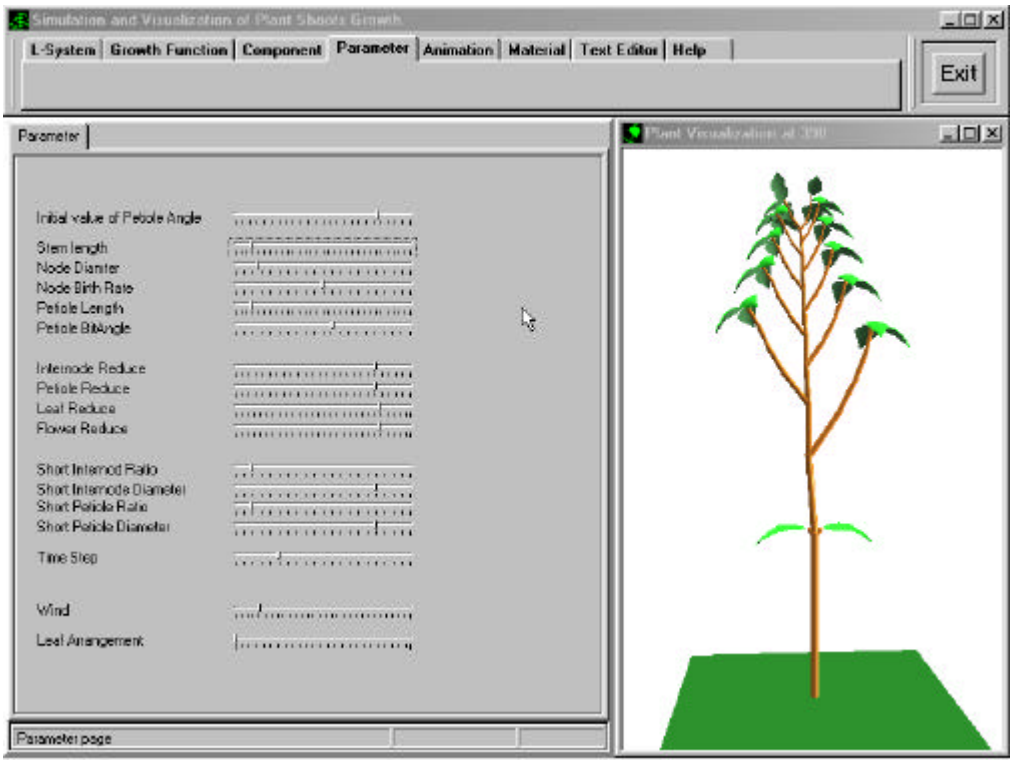


**Figure C-27: Adjust the appropriated parameter.**

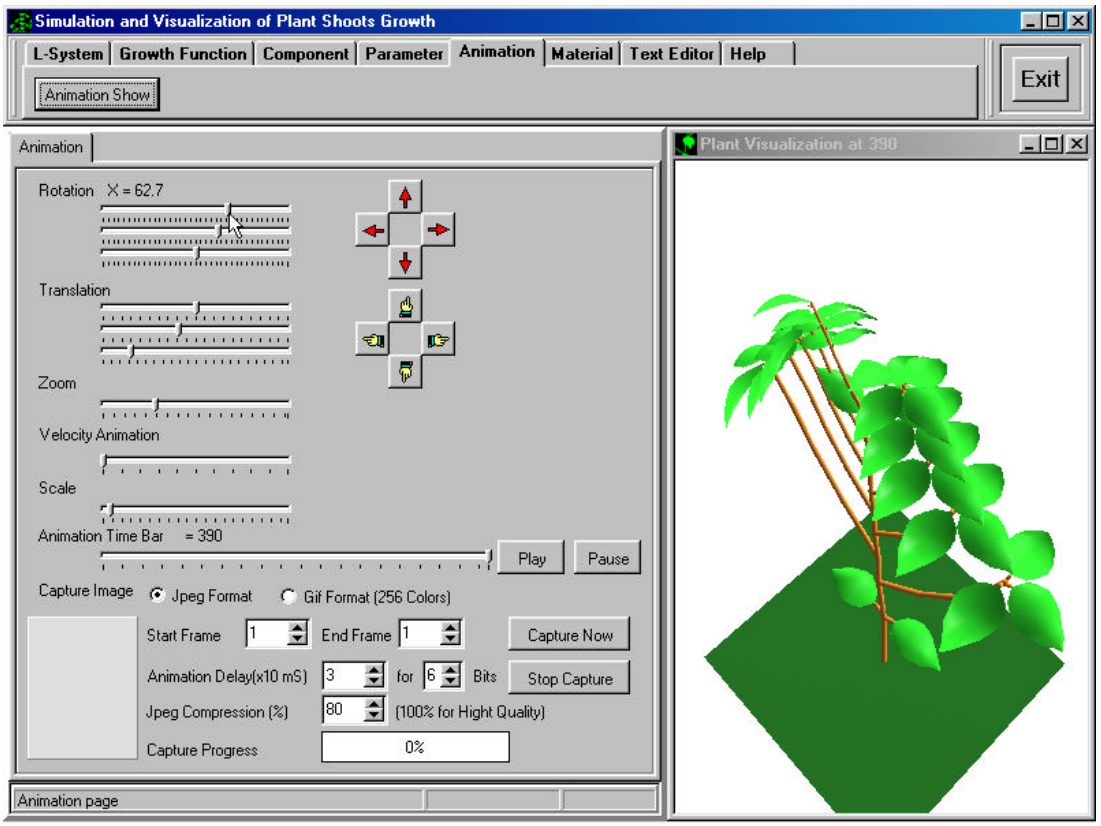


**Figure C-28: The top view of plant.**

To show the top view of the plant model, click the animation page and click the rotation trackbar. The result will be shown as Figure C-28.

## 6. The material page

The material page is used to set the color of each component such as the internode, the petiole, front leaf, back leaf, front petal of the flower, back petal of the flower, the background, and the land. Especially, the used can design the leaf texture in order to map the leaf. The material page is shown in Figure C-29.

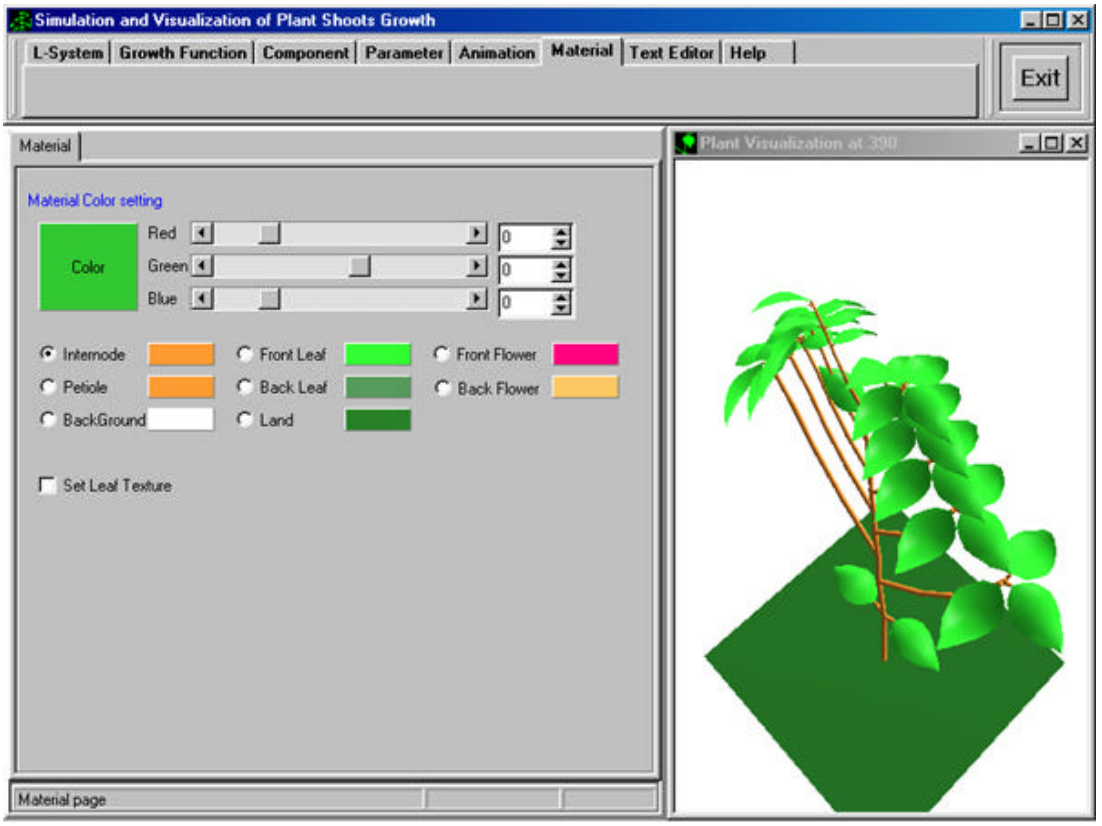


**Figure C-29: The material page.**

To set the leaf texture, click the check box “Set Leaf Texture” as Figure C-30. The material page will show the texture information. For example, select the leaf texture number two as Figure C-31. The result of texture mapping displays in Figure C-32.

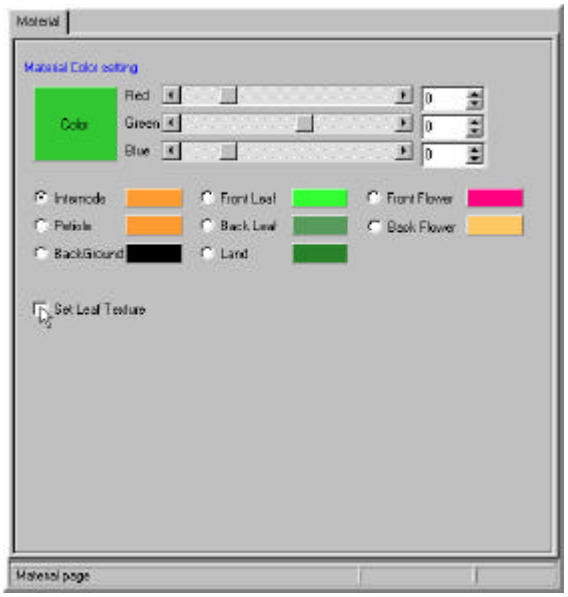


**Figure C-30: Select the texture of leaf .**

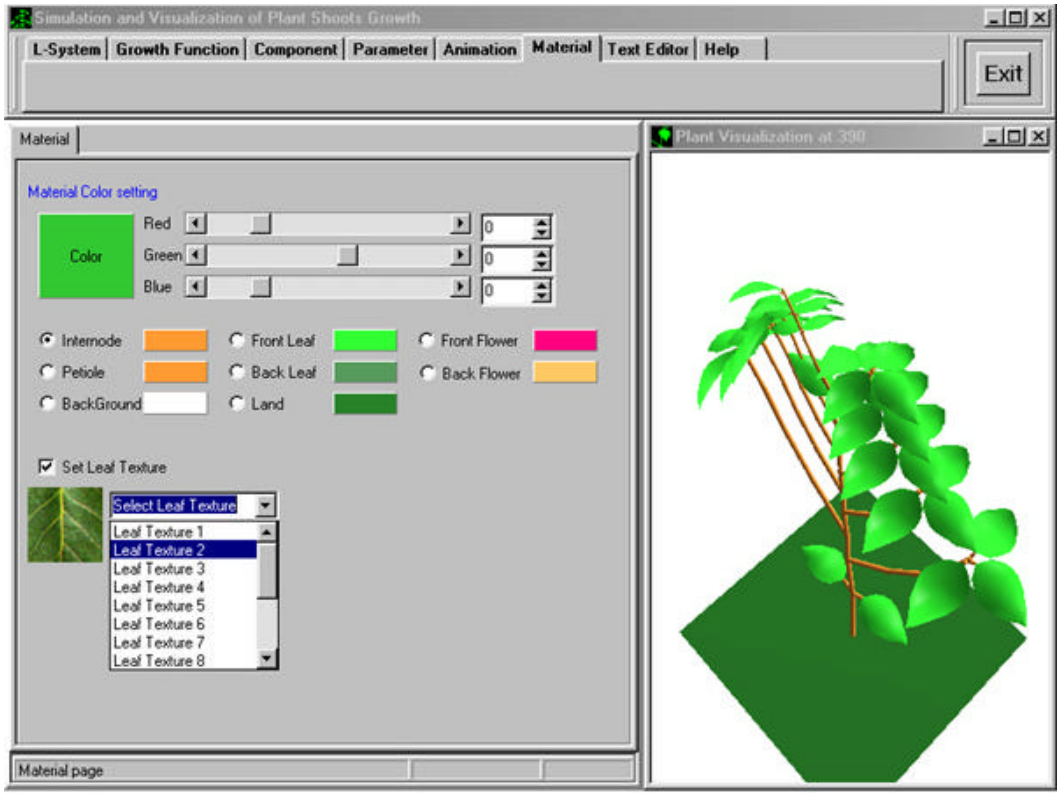


**Figure C-31: Select the leaf texture 2.**

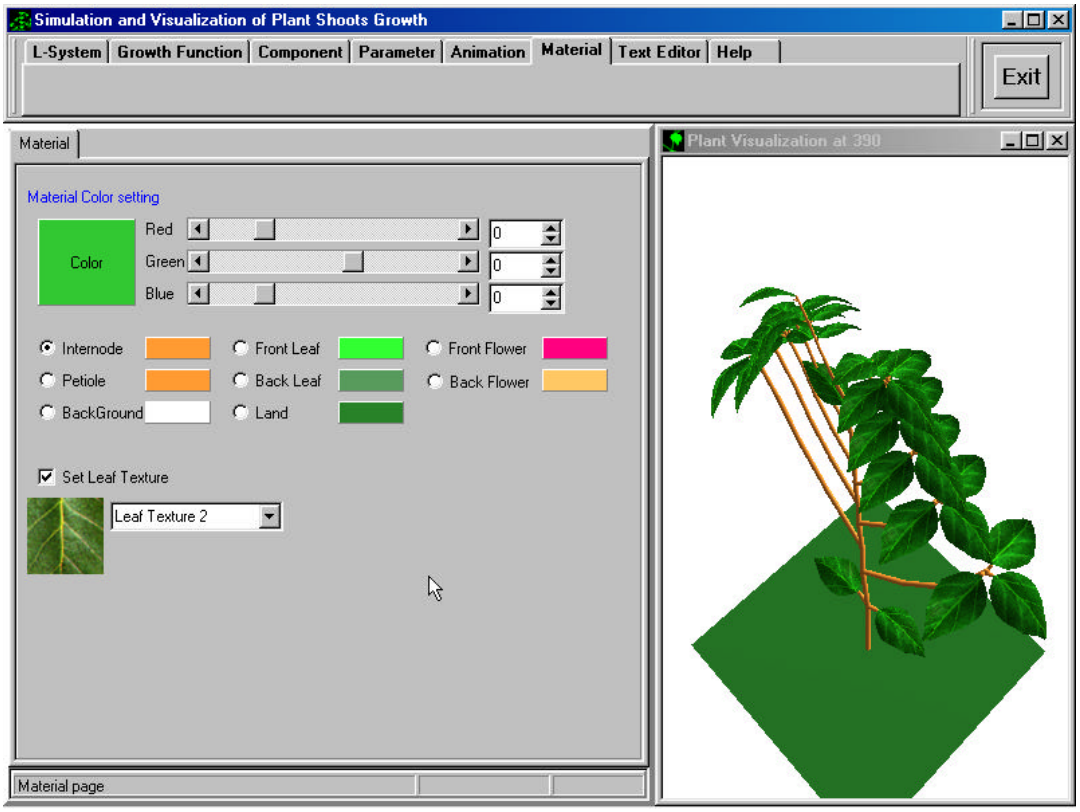


**Figure C-32: The result of texture 2.**

To open the soybean texture, click the texture image. Select the soybean texture as Figure C-33.

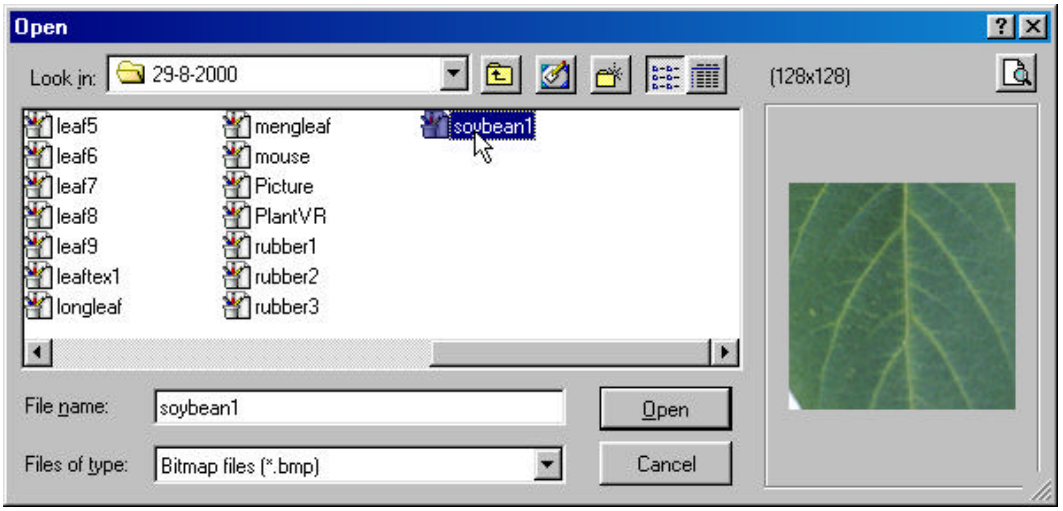


**Figure C-33: Open soybean texture.**

Click “Open” button. The result displays in the Figure C-34.

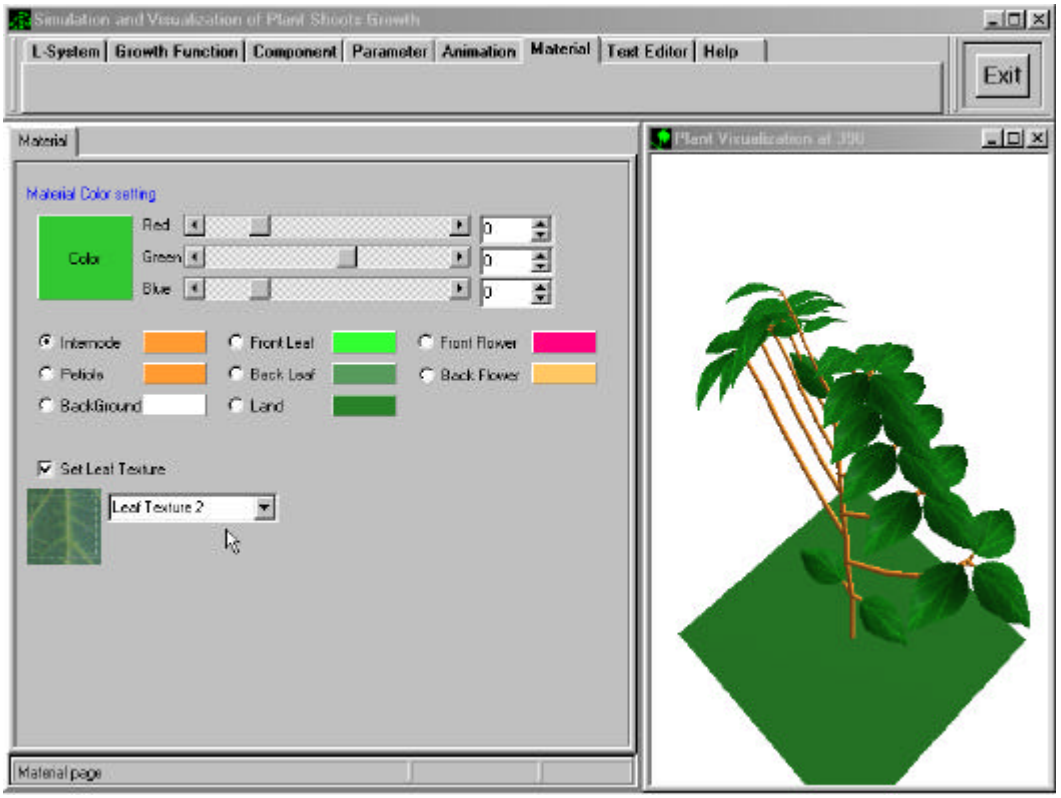


**Figure C-34: The result after selecting the soybean texture.**

To change the internode color, click the radio button “Internode” and adjust the preferred color. The plant shows the internode color immediately as Figure C-35.

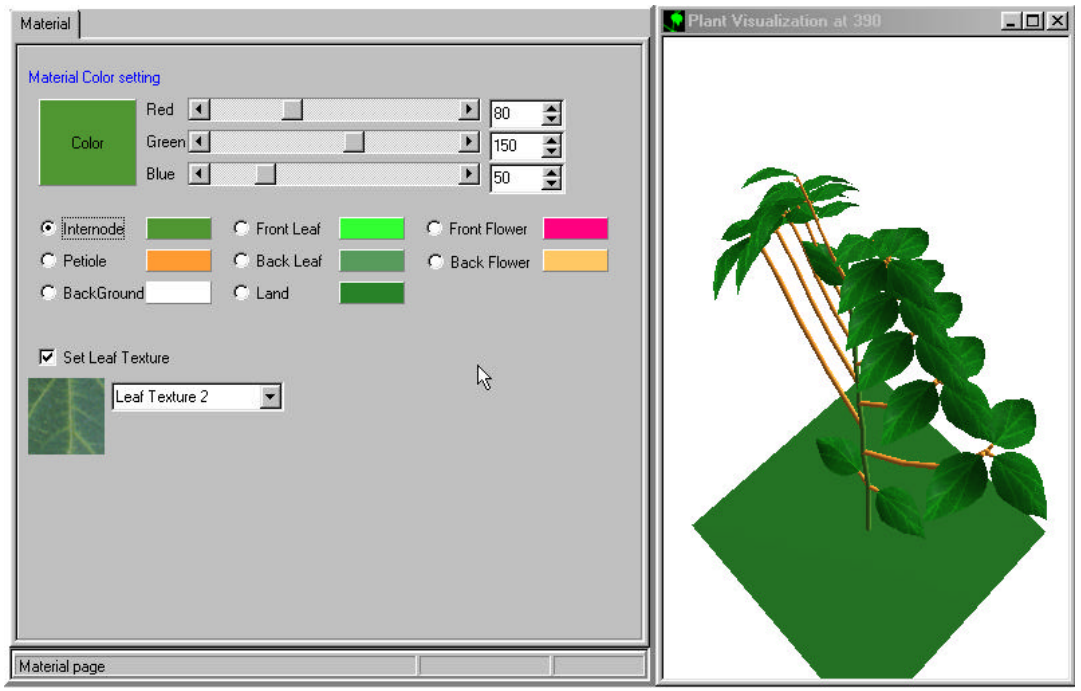


**Figure C-35: Set the internode to green color.**

Click the radio button “Petiole” and adjust the color of petiole like internode. The petiole color will show in Figure C-36.

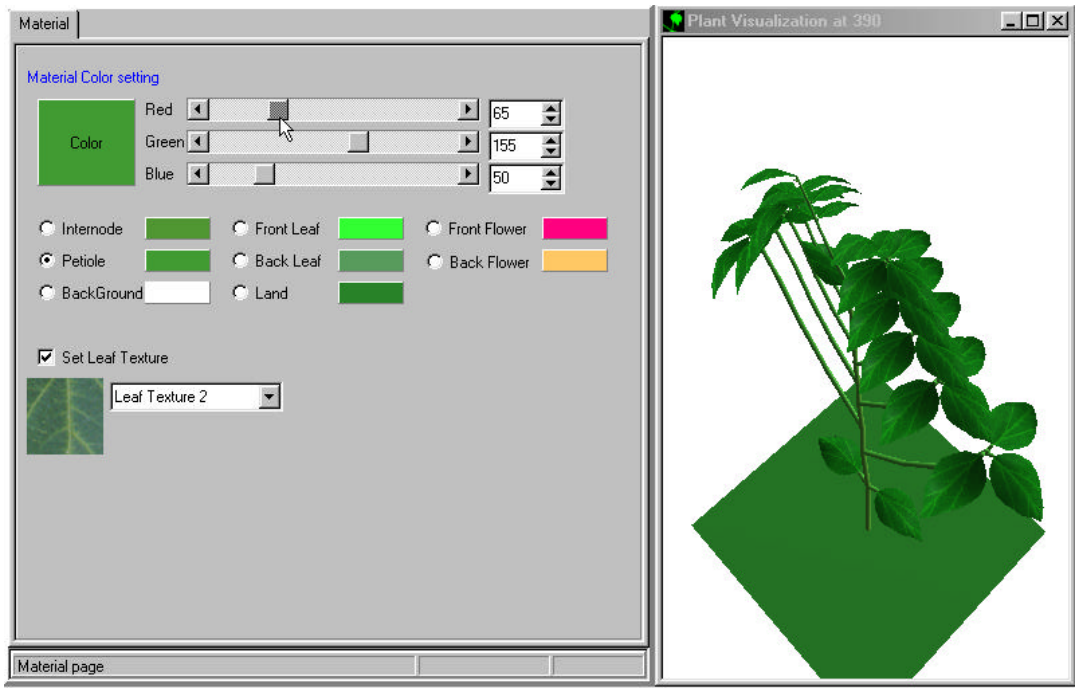


**Figure C-36: Set the petiole to green color.**

To adjust the perspective view as Figure C-37, click the animation page, and adjust the rotation trackbar.

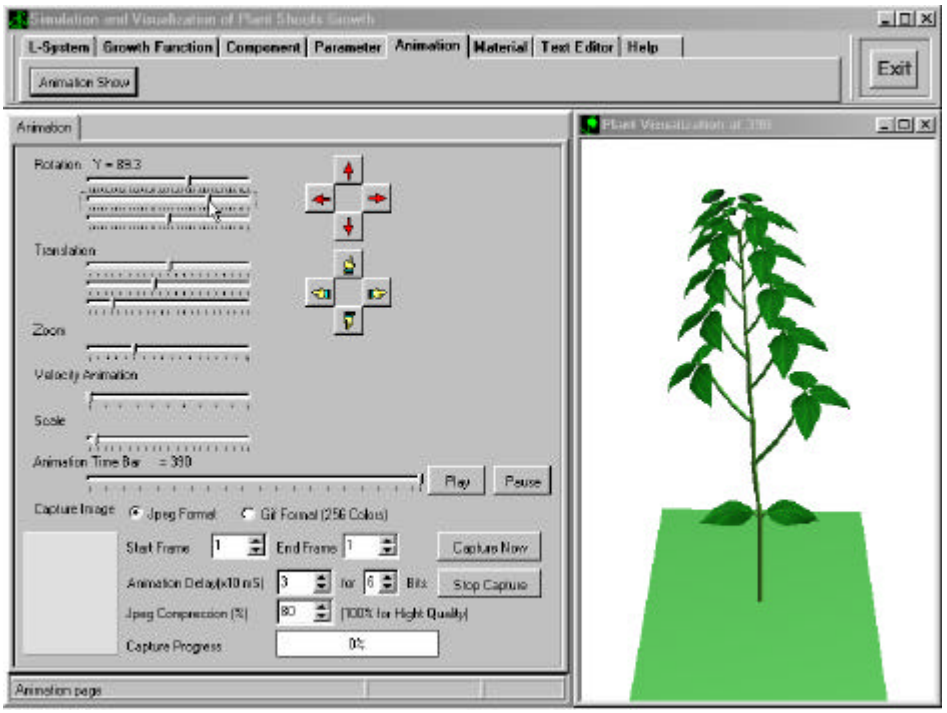


**Figure C-37: Adjust the new perspective view.**

To show the plant development at any time step, click the trackbar "Animation Time Bar". For example, adjust the animation time bar at 19, the plant development is shown in Figure C-38.

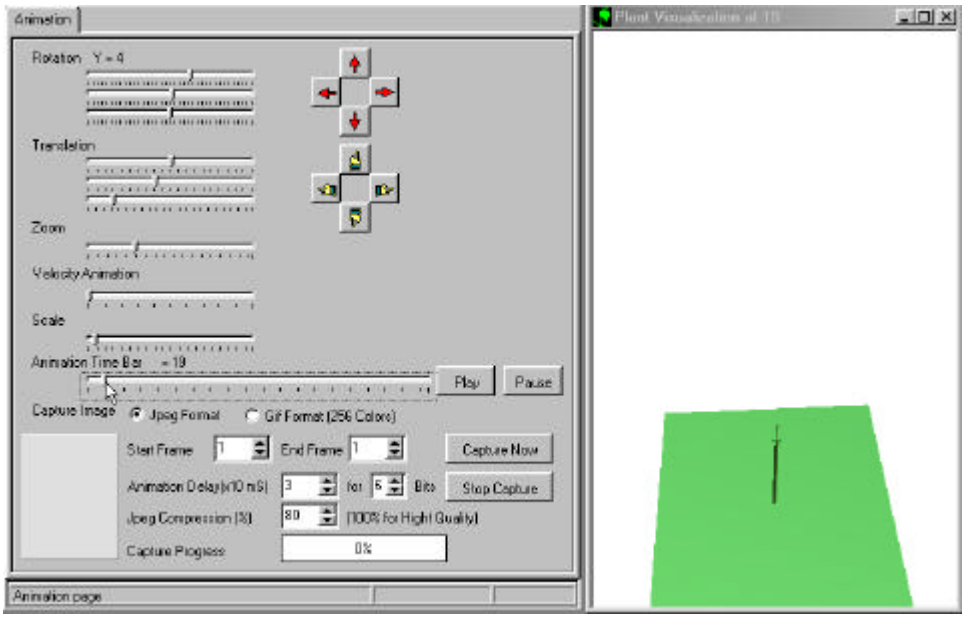


**Figure C-38: The animation of plant growth at time 19.**

At the time 53, the plant development is displayed as Figure C-39.

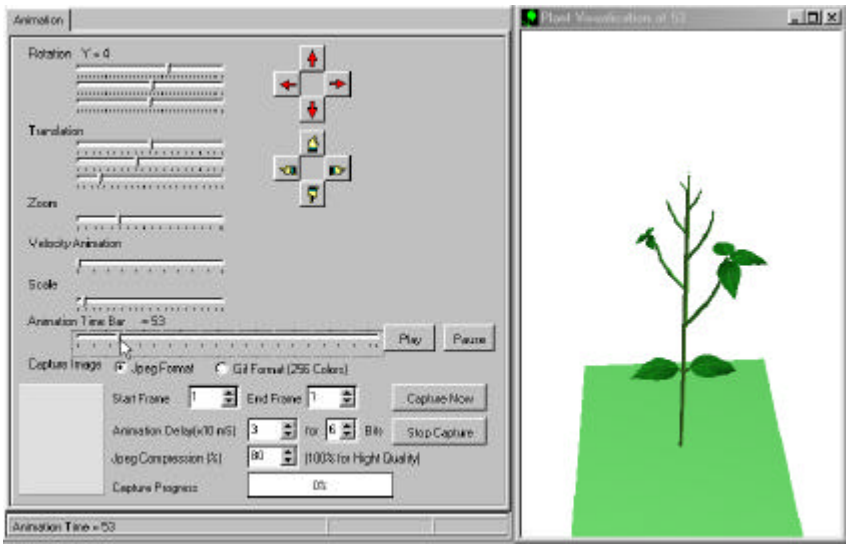


**Figure C-39: The animation of plant growth at time 53.**

At the time 75, the plant growth is shown in Figure C-40.

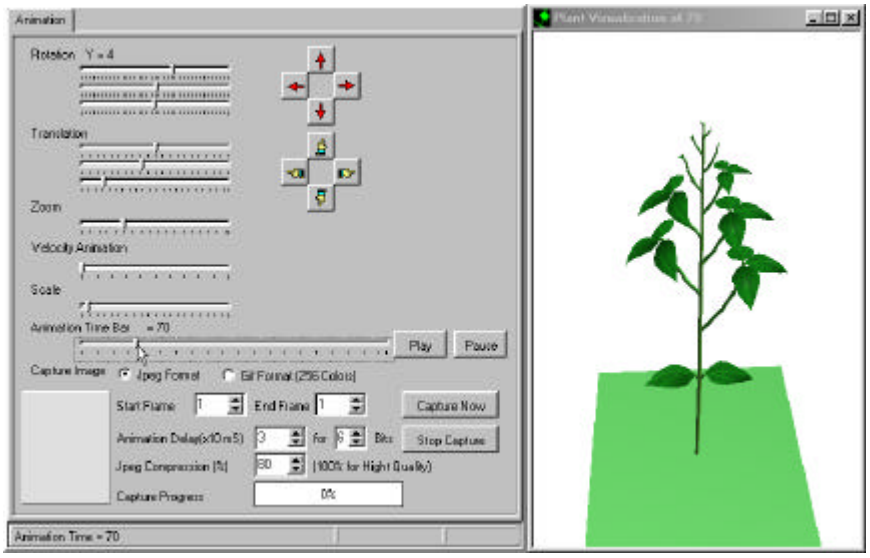


**Figure C-40: The animation of plant growth at time 75.**

At the time 172, the result will be shown in Figure C-41.

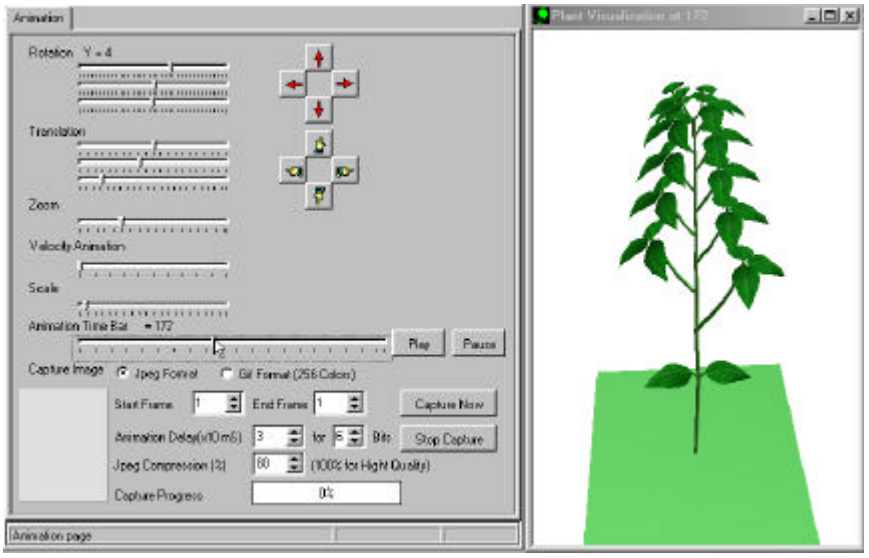


**Figure C-41: The animation of plant growth at time 172.**

To export the animation output frame and the animation output file like GIF animation, adjust the appropriated parameter such as the animation delay (set the value to one for fastest) and the quality of the animation file (set the value to eight for high quality of GIF animation). Set the capture image type JPEG format or GIF format and the JPEG compression quality (set to 100 for high quality).

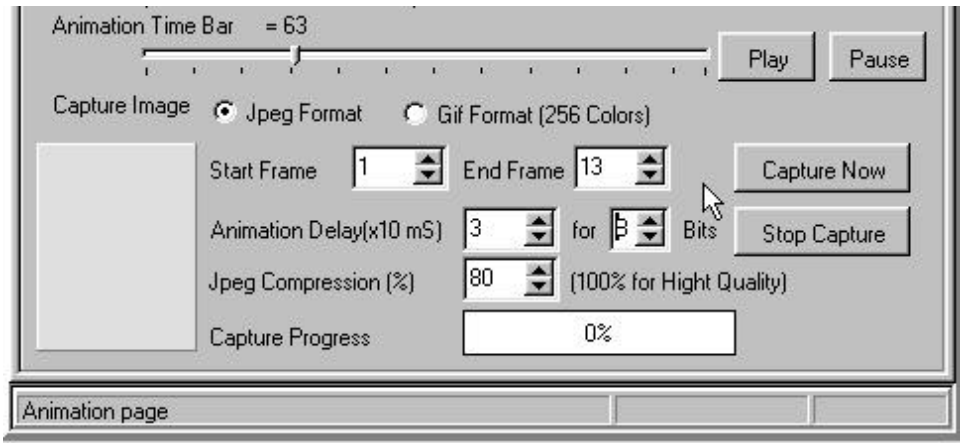


**Figure C-42: The capture setting.**

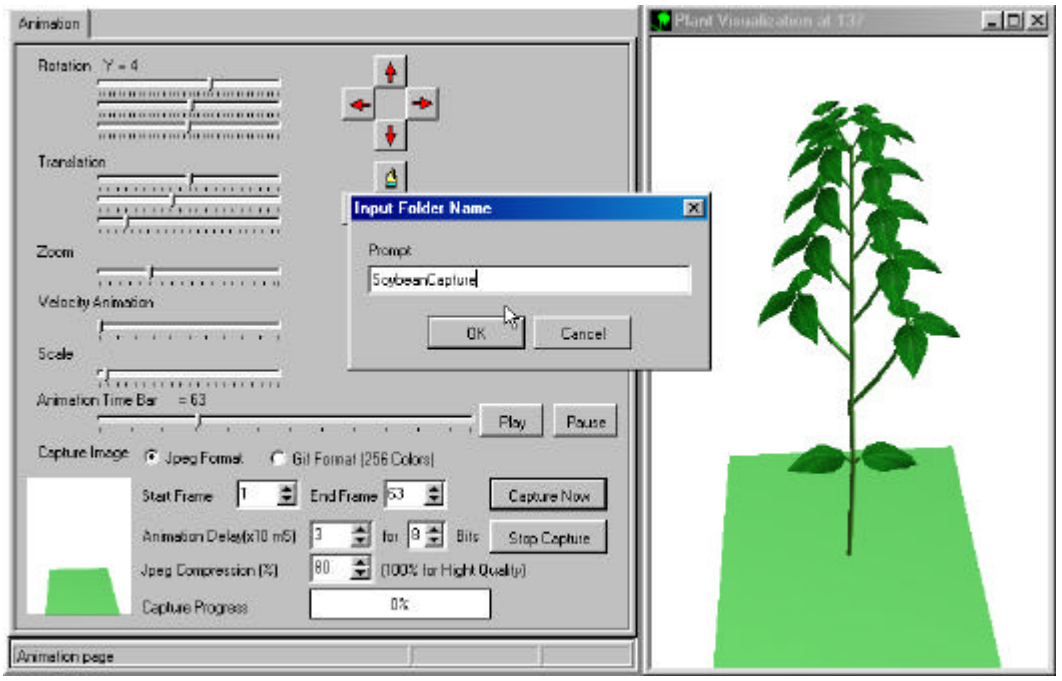


**Figure C-43: Input the target folder of animation frames.**

The animation is capturing using the plant visualization window. Don't open the other window that makes this window unclear. The user can set any parameter to include the changing to the output file such as rotation the plant model.

A snap short at sixty-nine percent is shown in Figure C-44. If you want to stop the animation, click the "Stop Capture" button.

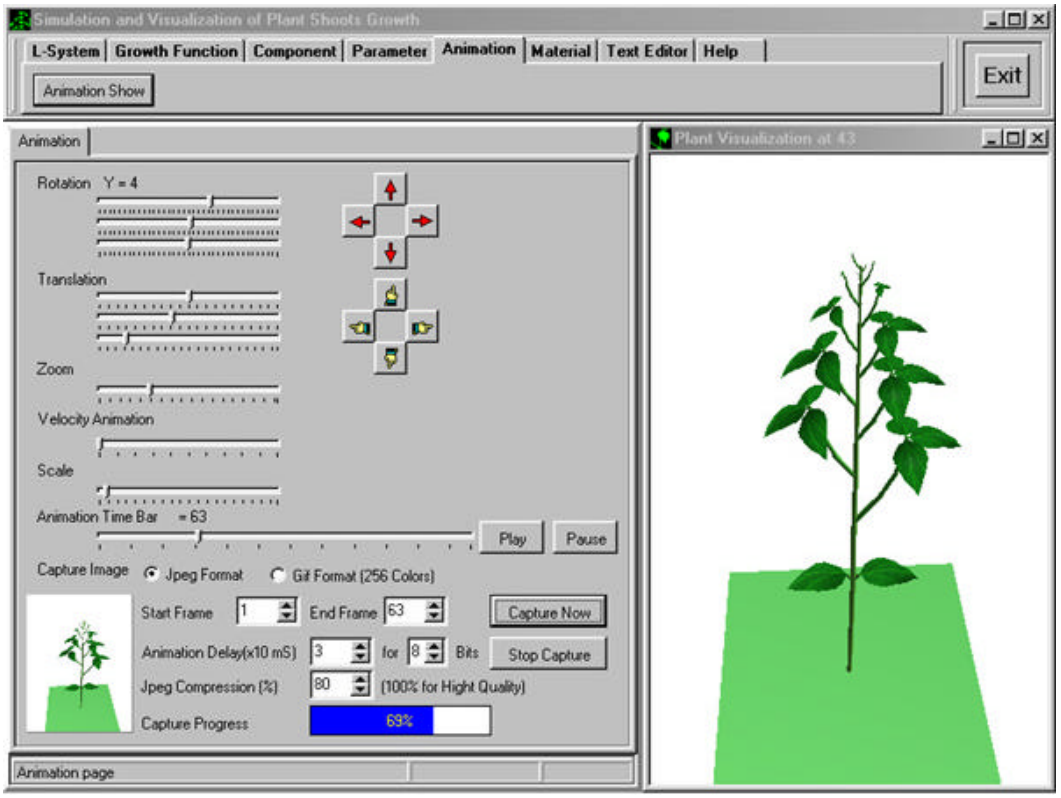


**Figure C-44: Capturing at sixty-nine percent.**

After the process has finished, the program shows the message “Capture Completed” as FigureC-45.

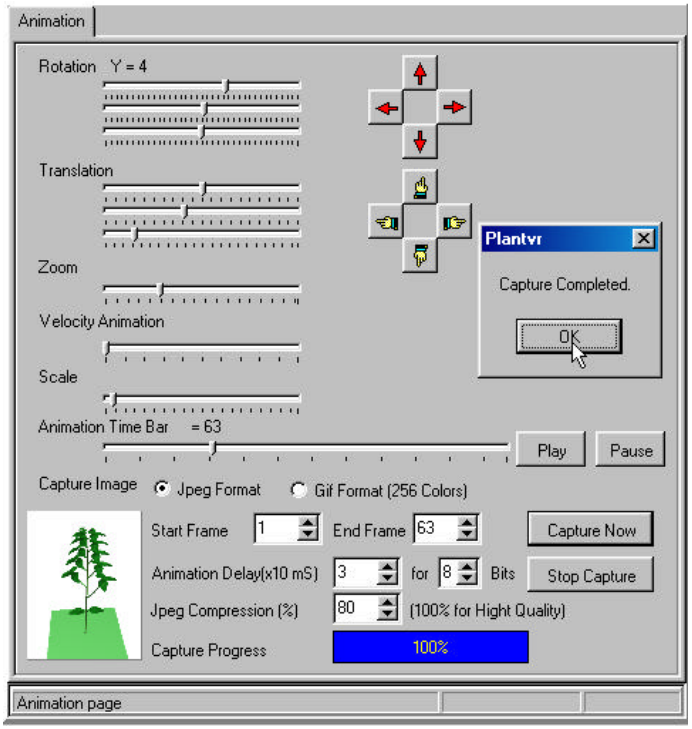


**Figure C-45: Capture complete.**

In the folder, the system creates the new folder name “Soybean Capture” and shows the list of animation frames picture1.jpg to picture63.jpg for each development time as Figure C-46.

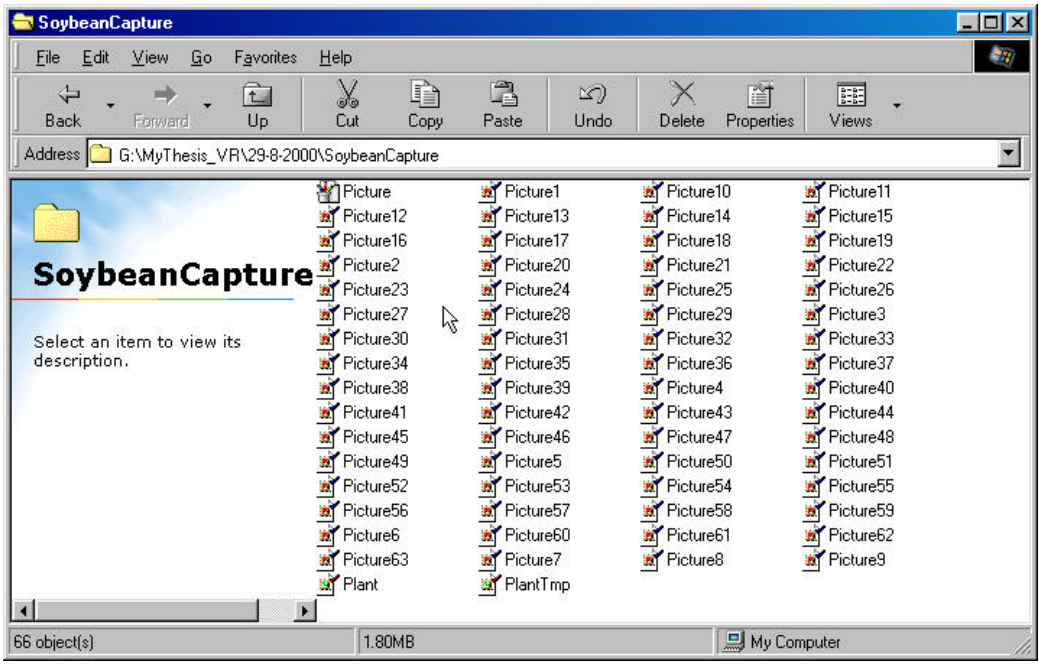


**Figure C-46: The list of animation frames and the animation file.**

The file picture.bmp is the last frame at the time 63. The plant.gif file is the animation file is available show on the web browser, and the temporary file planttmp.gif for the backup of the animation file in the case of captured failure. The Figure C-47 shows the plant model after completed capturing.

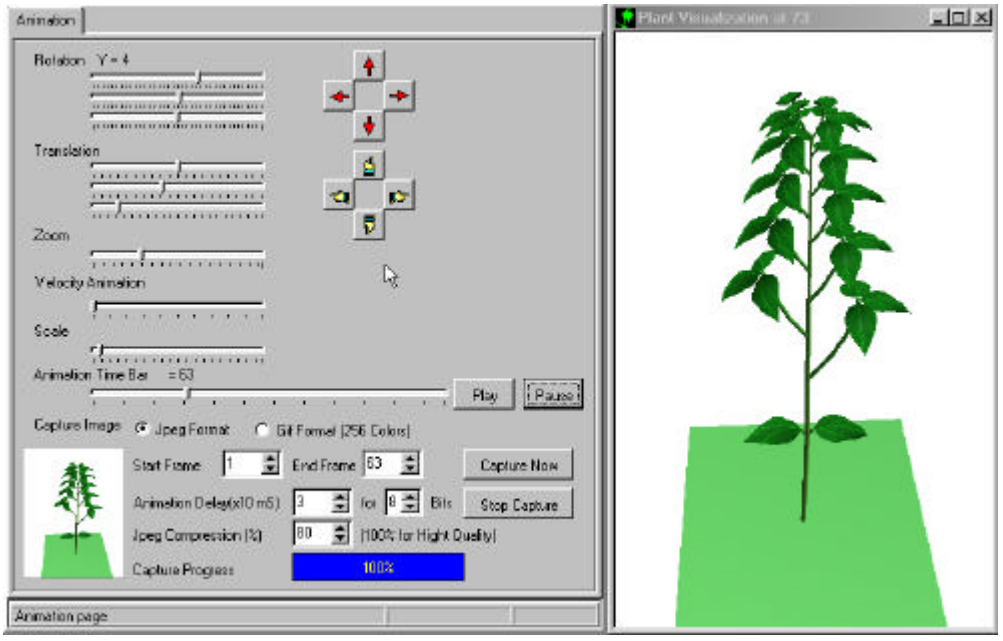


**Figure C-47: The plant model after capturing complete.**

## 7. Create a new plant

To create a new plant model, select the text editor page to copy the L-system code as Figure C-48, and paste to the L-system editor in the L-system page as Figure C-49. In the other way, type the new L-system code in the L-system editor.

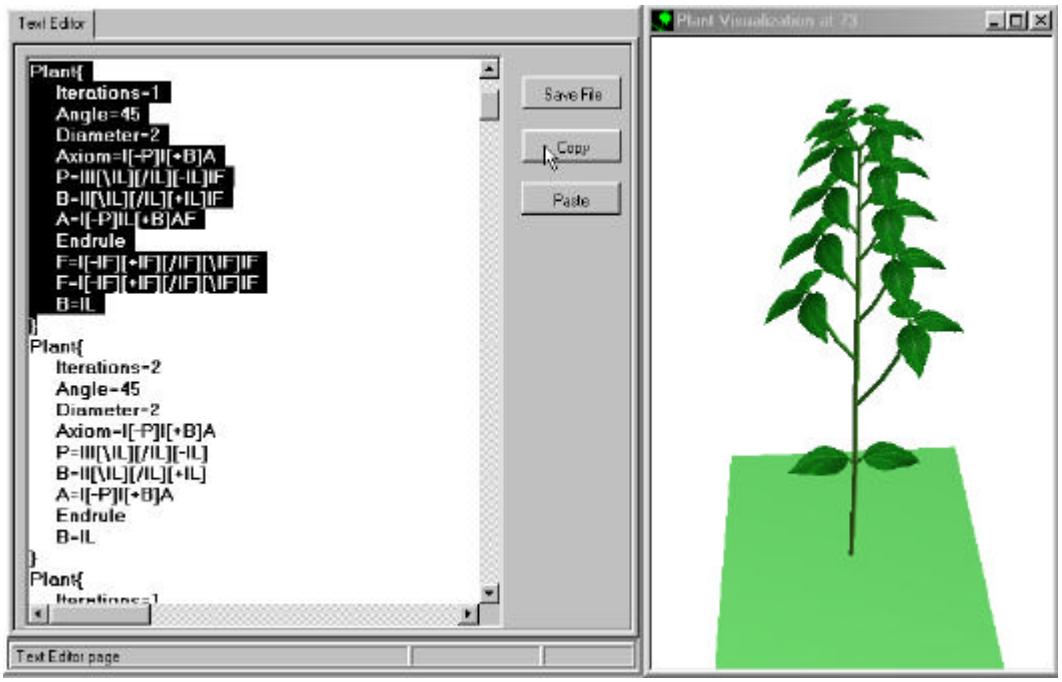


**Figure C-48: Copy a new plant prototype to create the new plant.**

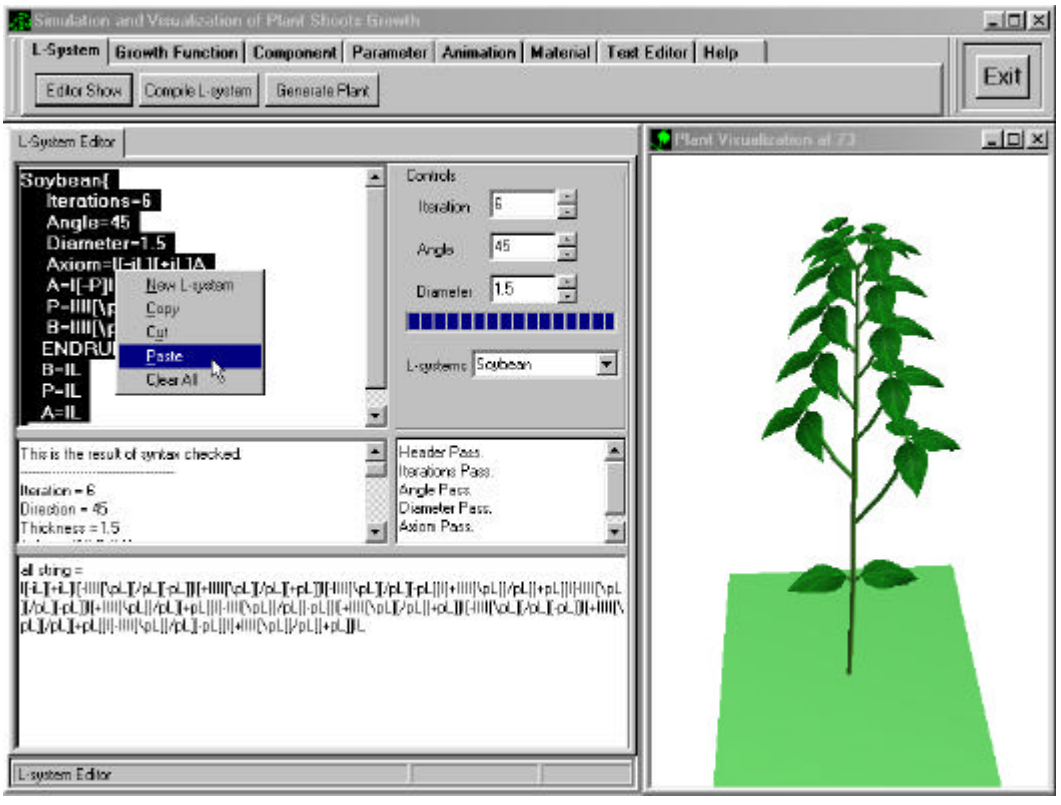


**Figure C-49: Select all and paste to the soybean prototype.**

Recompile and regenerate the plant, the old plant will active follow the diameter of new L-system code as Figure C-50.

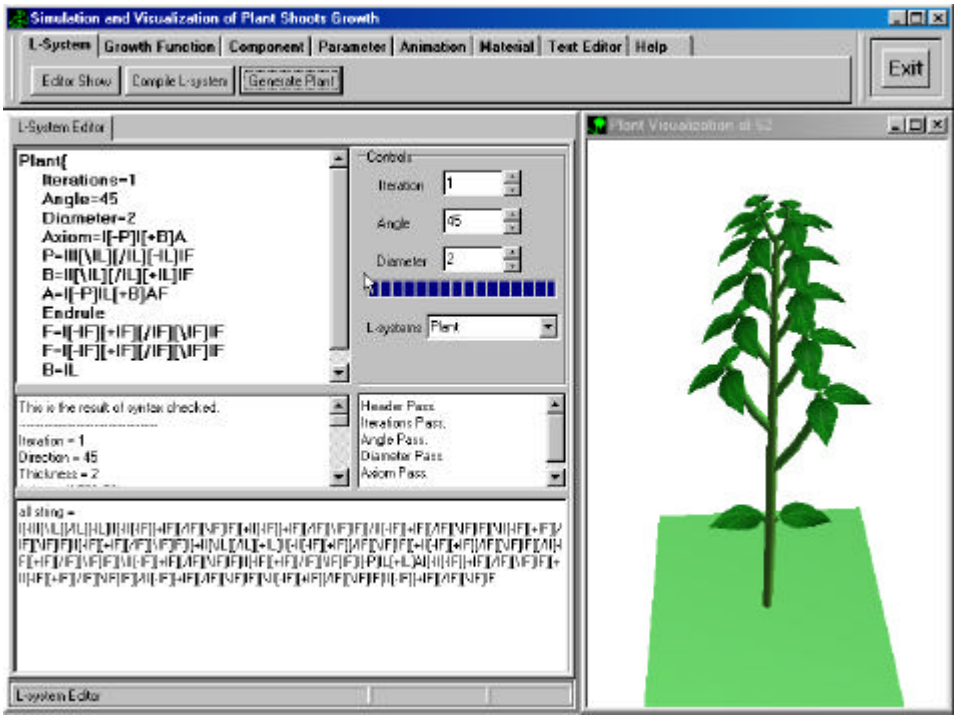


**Figure C-50: Compile and generate the plant prototype.**

The new plant model will be shown as Figure C-51 after the “Animation Show” is activated.

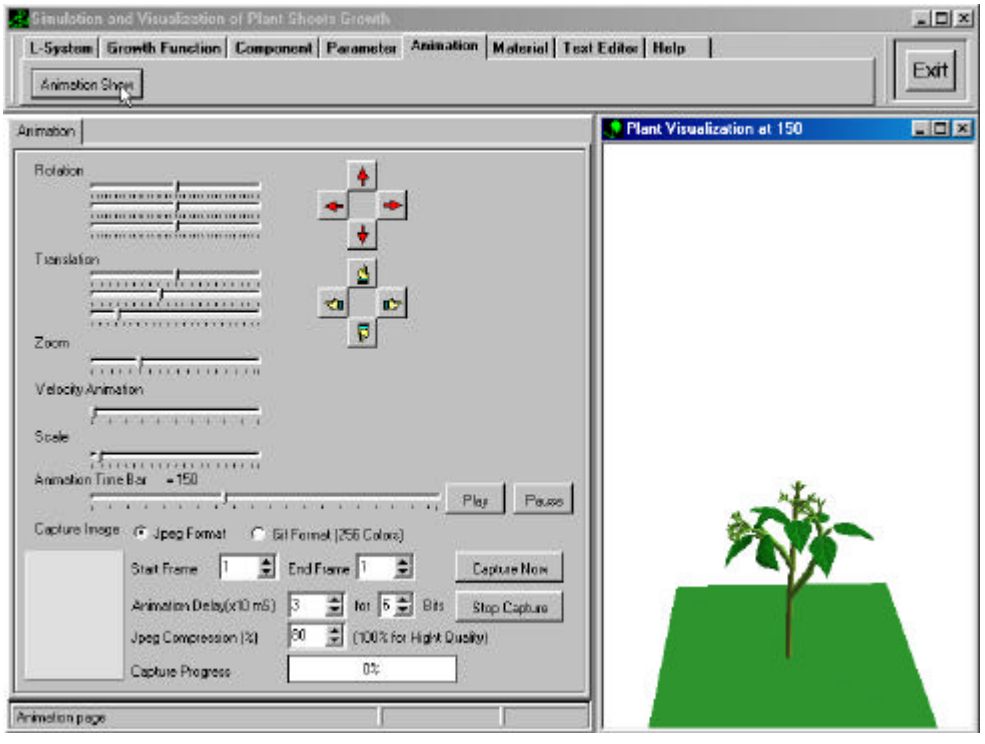


**Figure C-51: The result after generating a new plant.**

In the L-system string, there are the symbol "*F*" for flower component, the user must select the flower of plant such as select the petal of violet 2 as Figure C-52, but the flower are not shown.

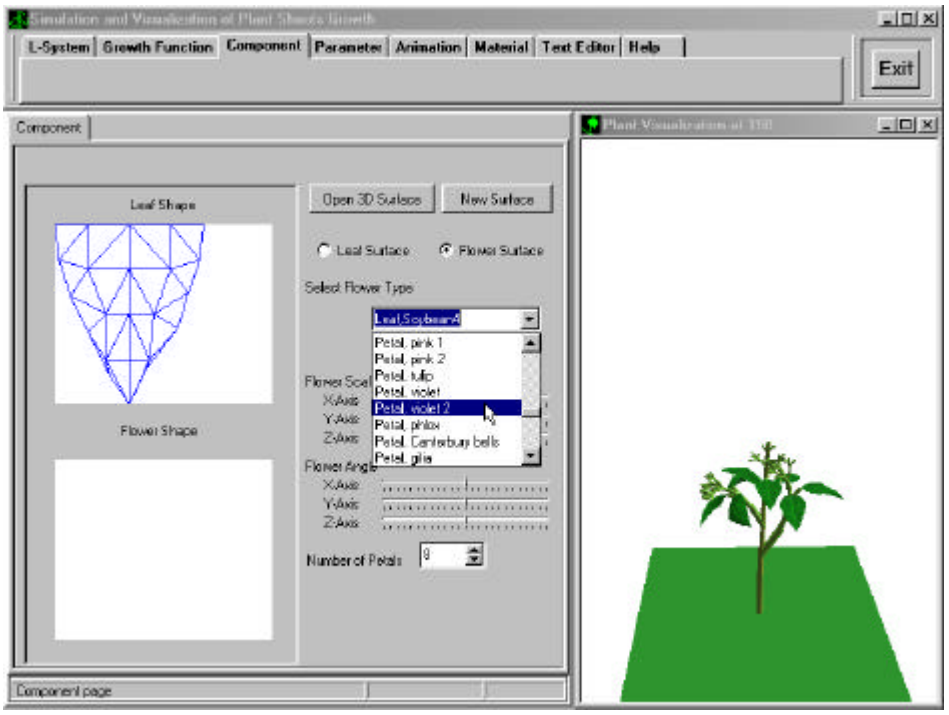


**Figure C-52: Select the flower from the library.**

To check the flower growth function, read data and fit the curve of flower, the flowers are shown in Figure C-53.

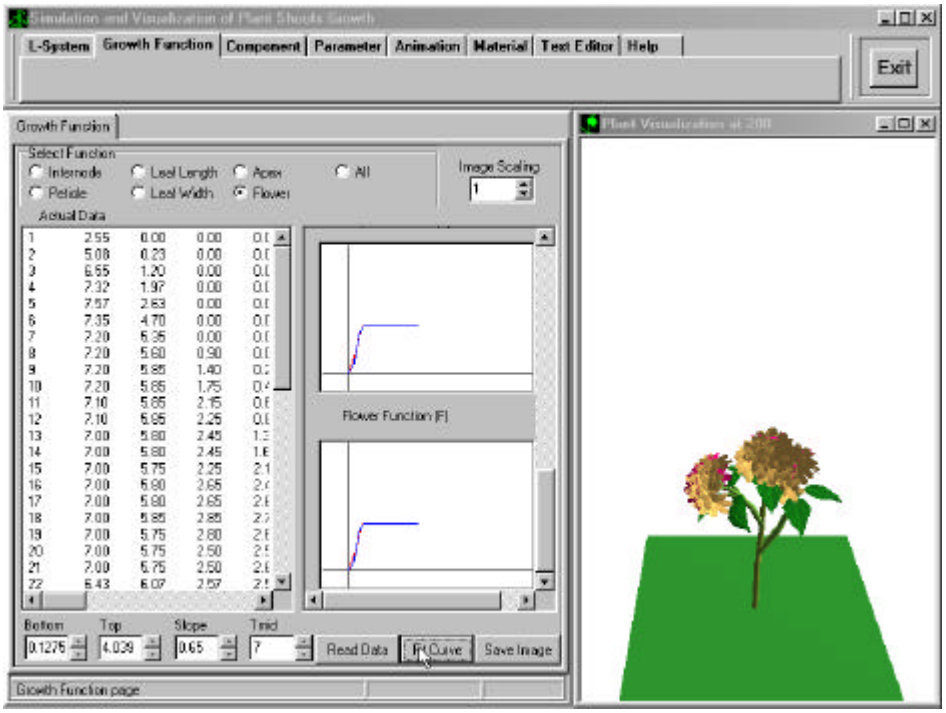


**Figure C-53: Set the flower growth function using internode data.**

To reduce the flower size, adjust the flower size as Figure C-54.

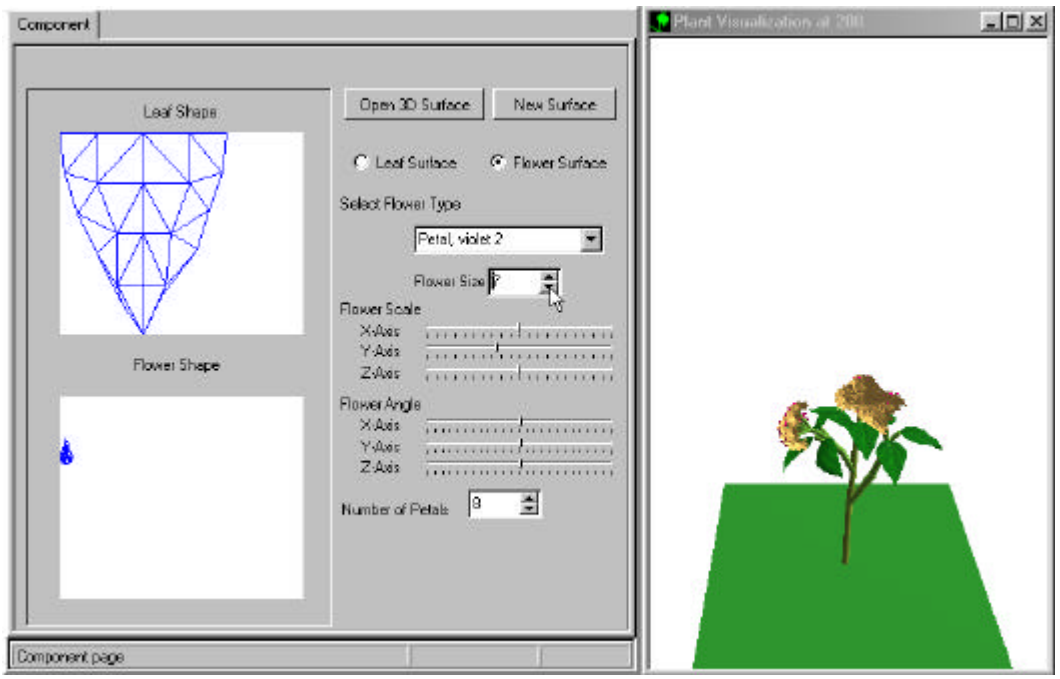


**Figure C-54: Adjust the size of flower.**

To set the appropriated plant, adjust the parameter such as the petiole length, the node diameter. The result will be shown as Figure C-55.

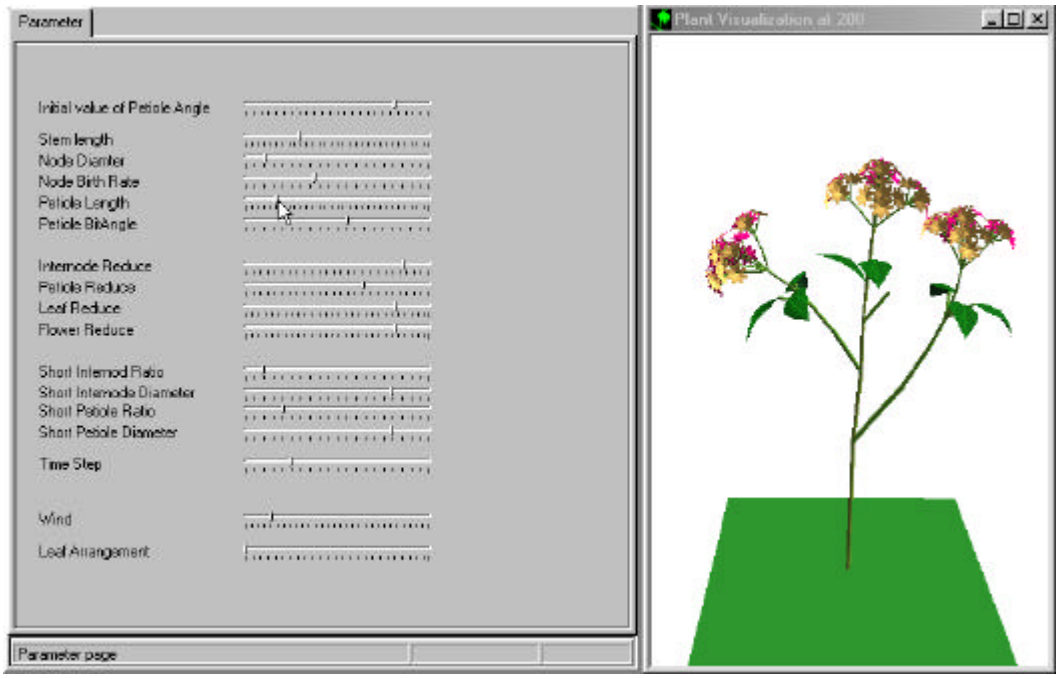


**Figure C-55: Adjust the appropriated parameter.**

To zoom in or translate the plant model to the appropriated perspective view, set the appropriated parameter in the animation page as Figure C-56.

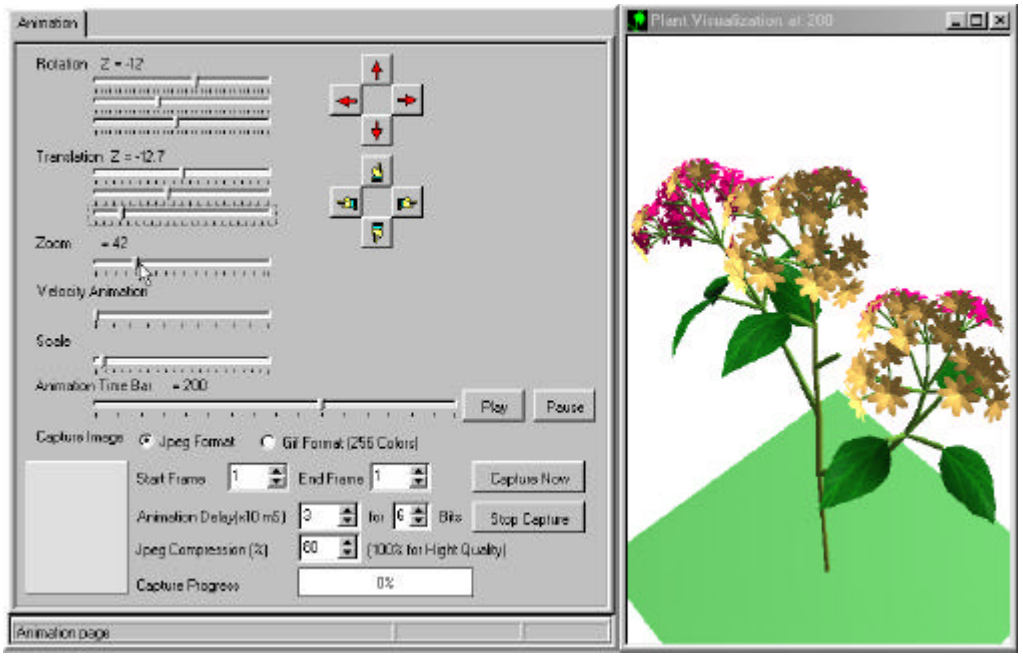


**Figure C-56: Adjust the appropriated perspective view.**

To change the leaf shape, select the component page and select the leaf type as Figure C-57 such as “leaf long serrated”.

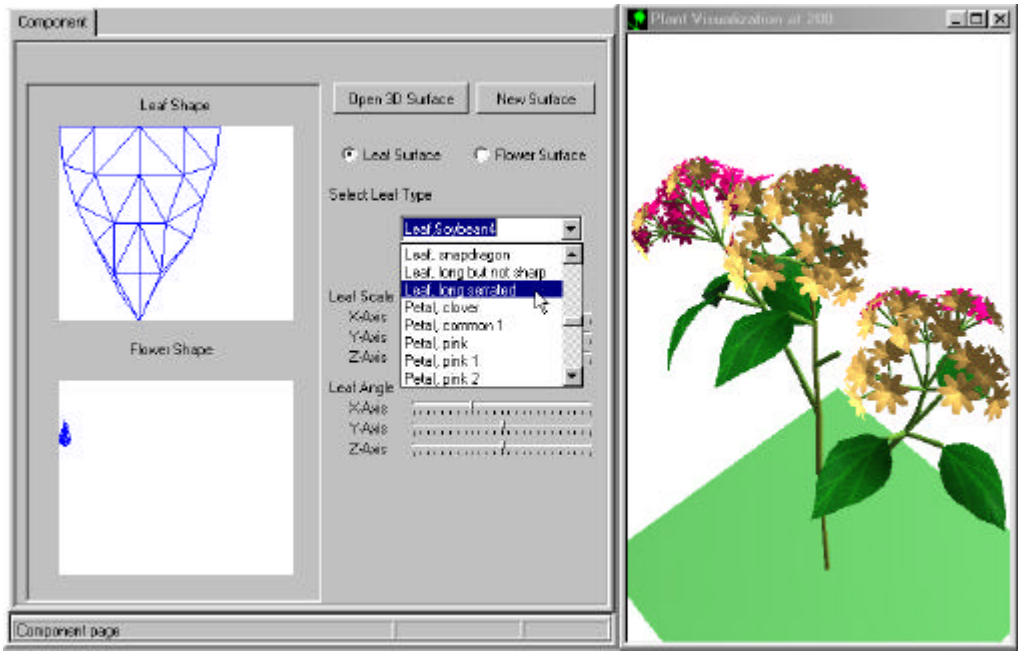


**Figure C-57: Change the leaf shape of plant.**

The new shape of leaf is shown in Figure C-58.

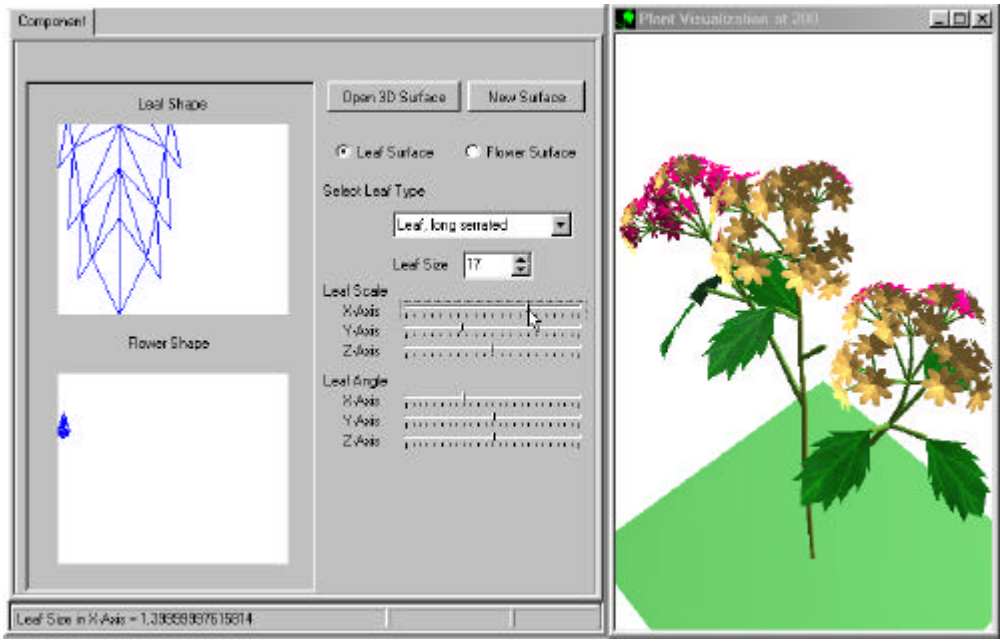


**Figure C-58: The result after selecting the new shape of leaf.**

To edit the new texture of leaf, click the texture image in the material page, and select the texture file as Figure C-59.

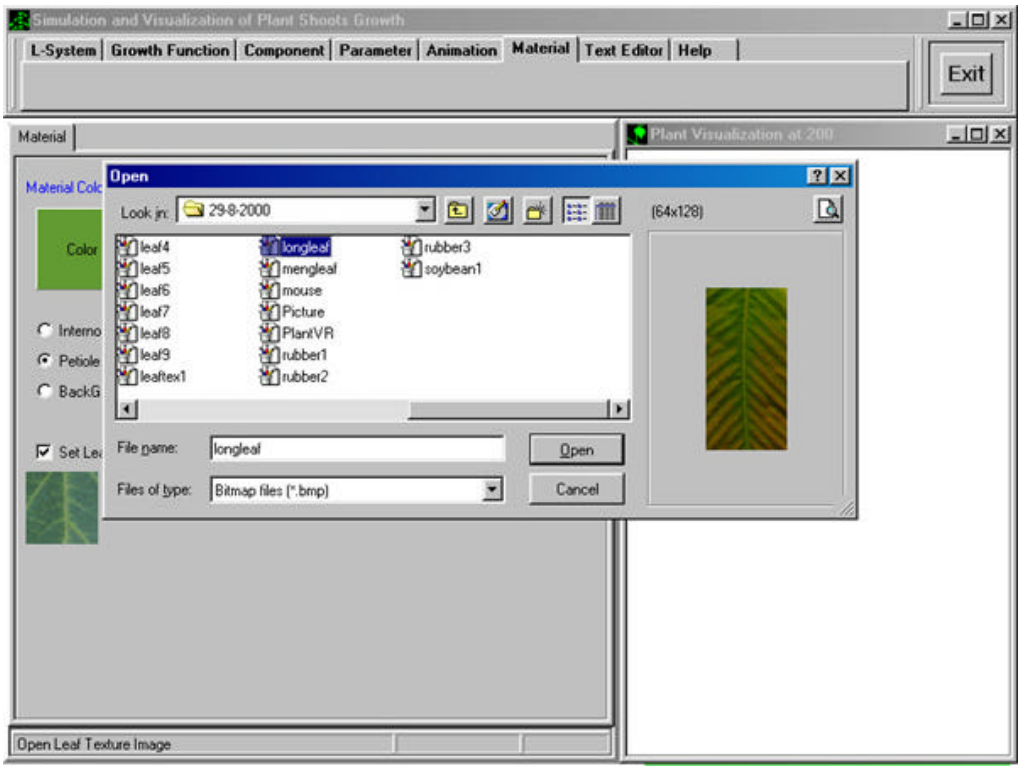


**Figure C-59: Change the new texture.**

The leaf shape is shown in Figure C-60 with the new leaf shape and its texture.

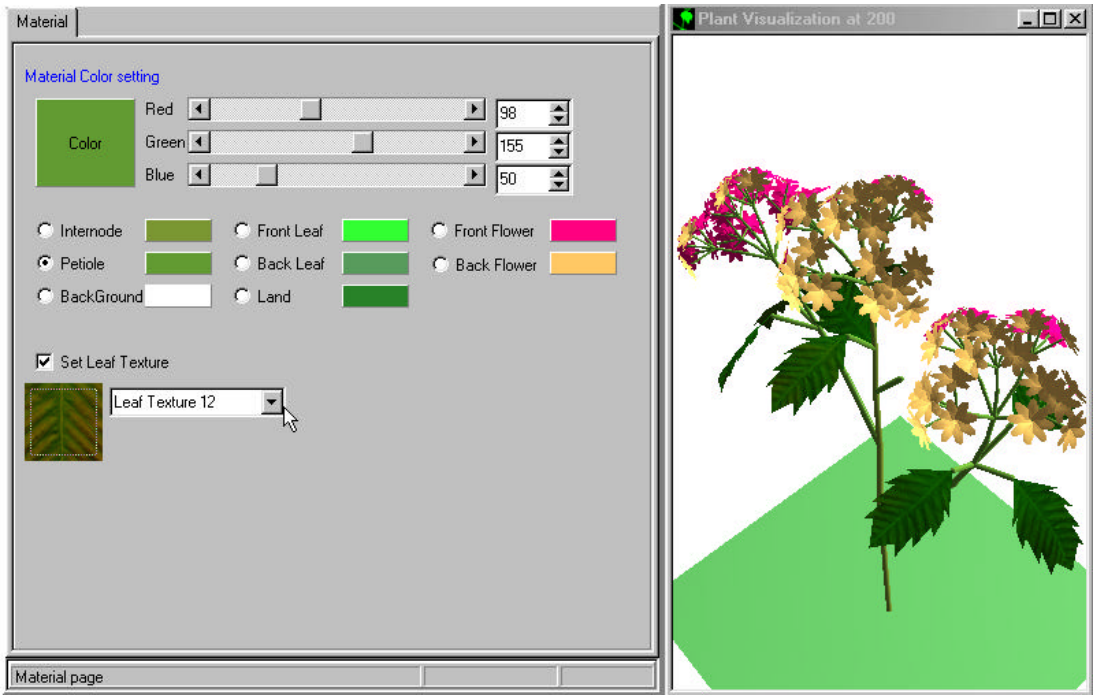


**Figure C-60: The new texture result after.**

To change the flower color, click the back or front of the flower radio button and adjust the preferred color as Figure C-61.

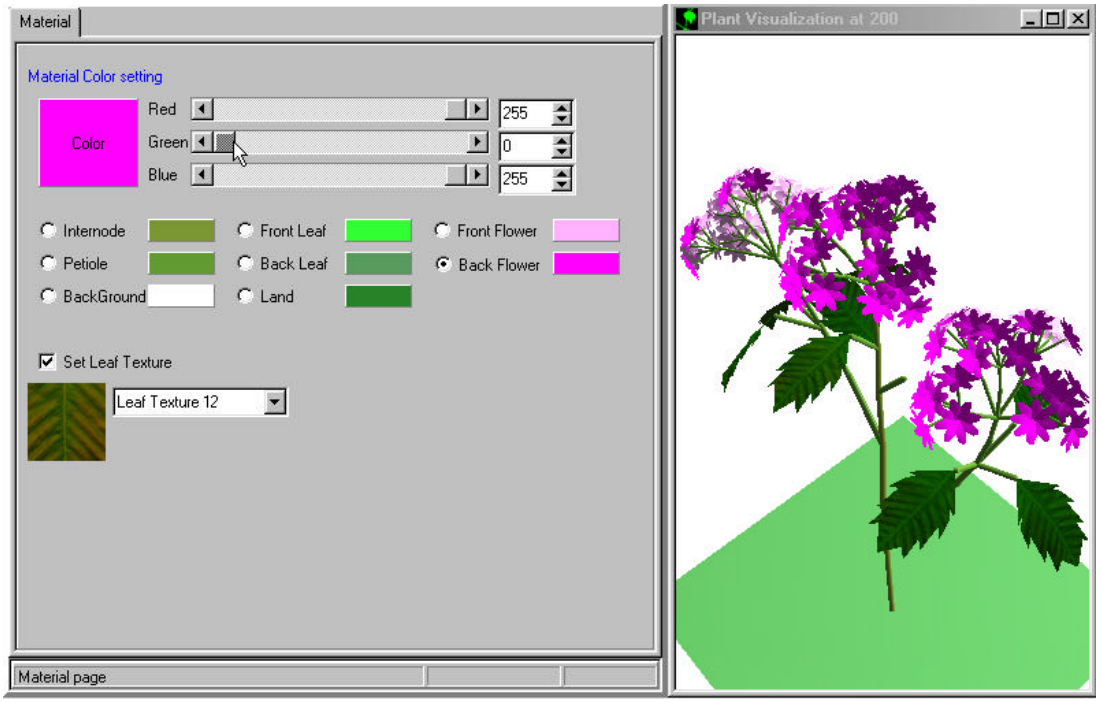


**Figure C-61: Change the flower color.**

To show the full screen of the plant model, click the maximize button of the visualization window or double click on the plant model. The result is shown as Figure C-62.

**Figure C-62: The full screen of plant model.**

To zoom in the flower, adjust the parameter on the animation page. The result will be shown as Figure C-63.

**Figure C-63: Zoom in the flower.**

To change the petal shape of the flower, select the flower surface such as “petal, clover”. The result is shown as Figure C-64.

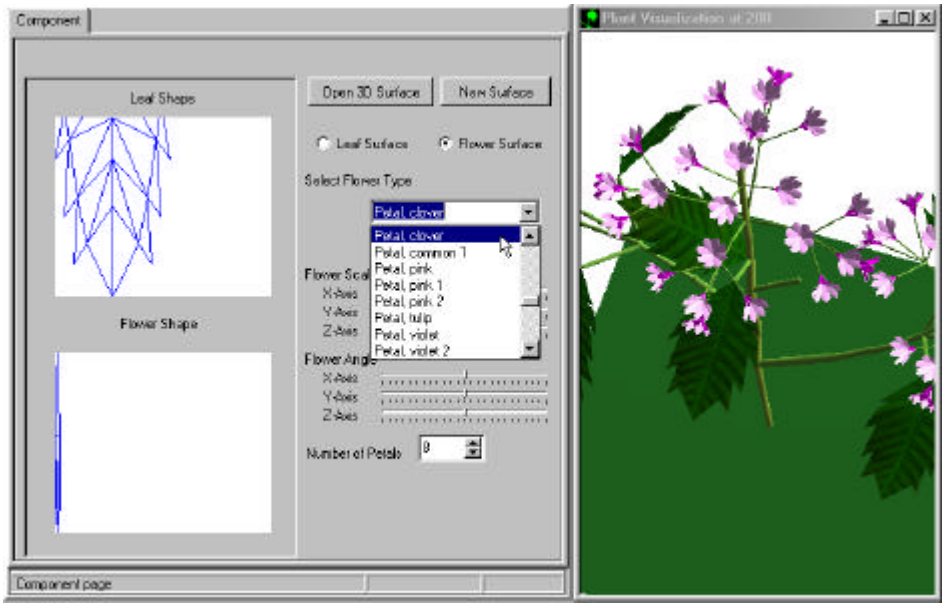


**Figure C-64: Change the flower shape.**

To set the flower color, select the material page and adjust the preferred color as Figure C-65.

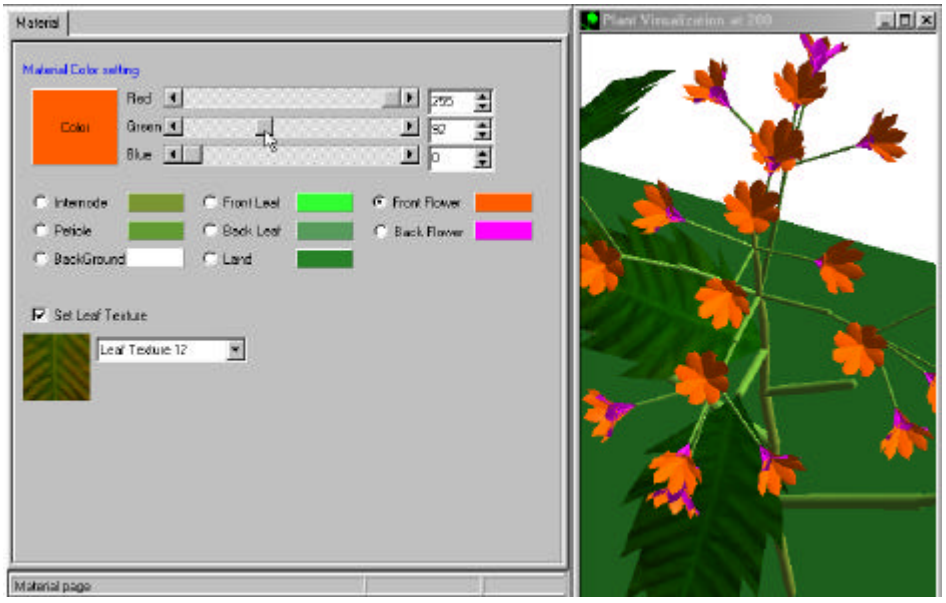


**Figure C-65: Change the flower color and perspective view.**

In the similar way, to change the new petal shape of the flower, select the component page, and select the petal type as Figure C-66.

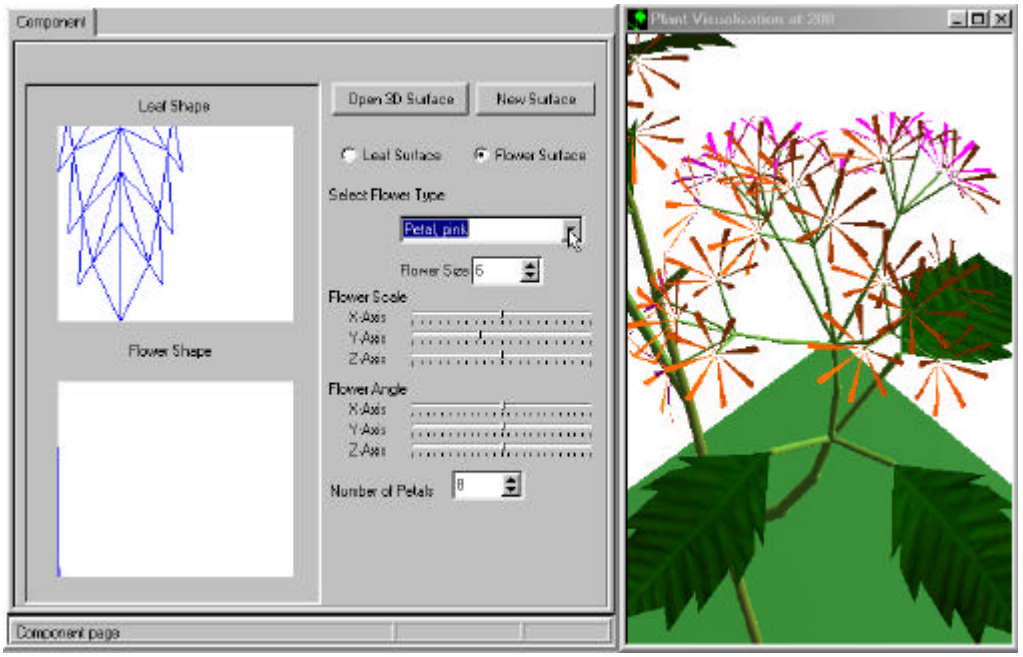


**Figure C-66: Change the flower shape.**

To change the number of flower petal, add the number of petal and the result will be shown as Figure C-67.

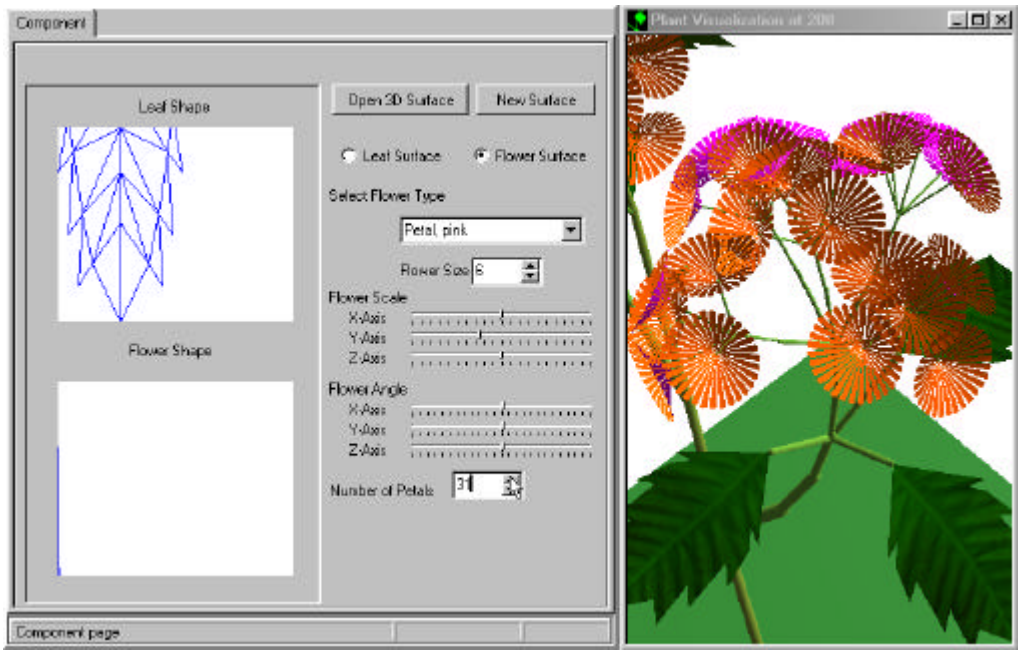


**Figure C-67: Add the number of petals.**

To change another petal shape, it will become the new plant in the same topology as Figure C-68, and Figure C-69.

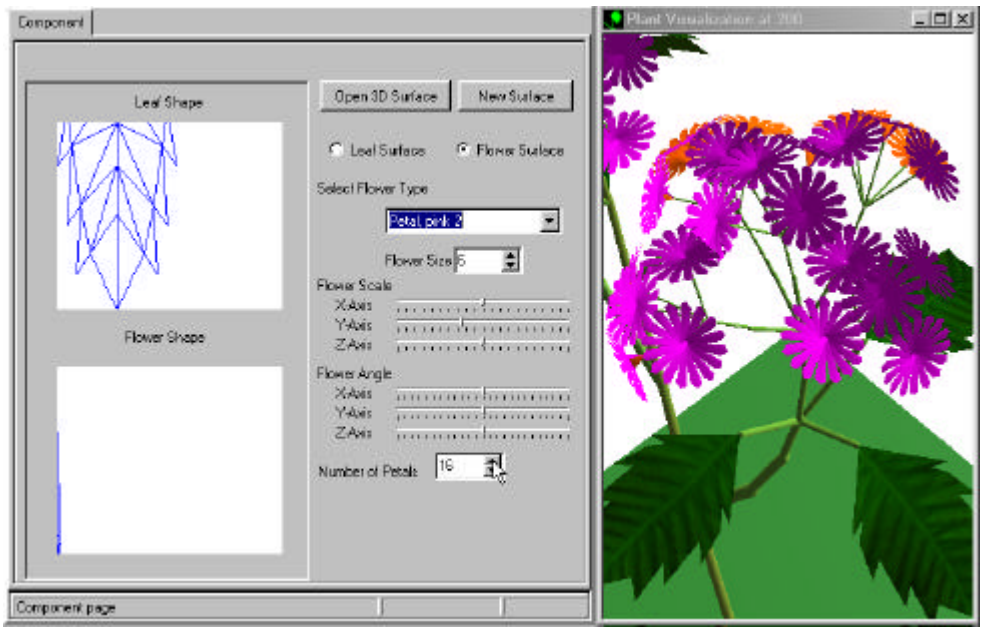


**Figure C-68: Change the flower shaper and the number of petals.**

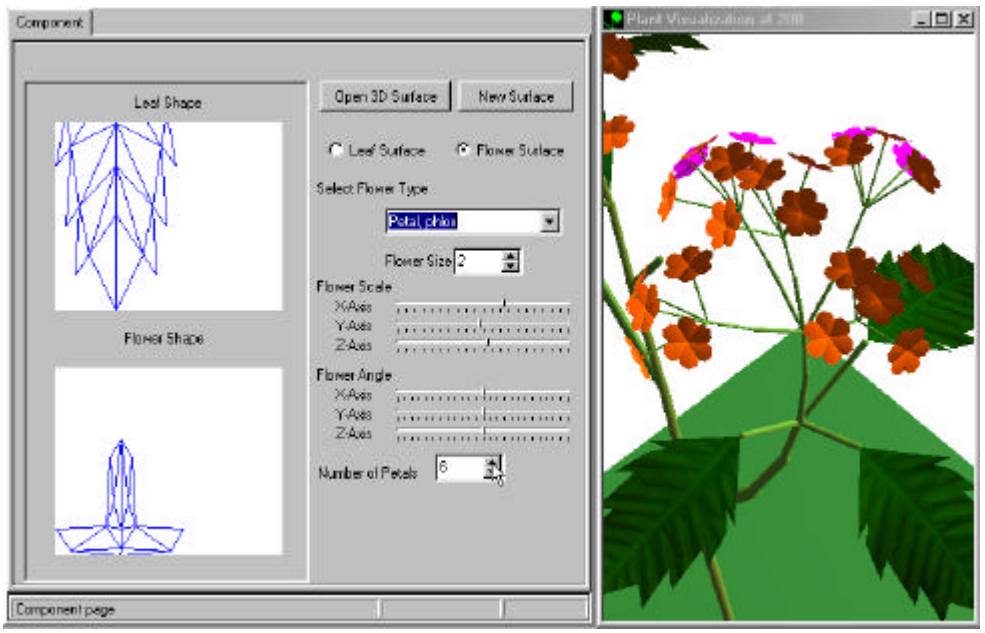


**Figure C-69: Change the and six petals.**

To show the new flower and the leaf color, Figure C-70 shows the new plant model.

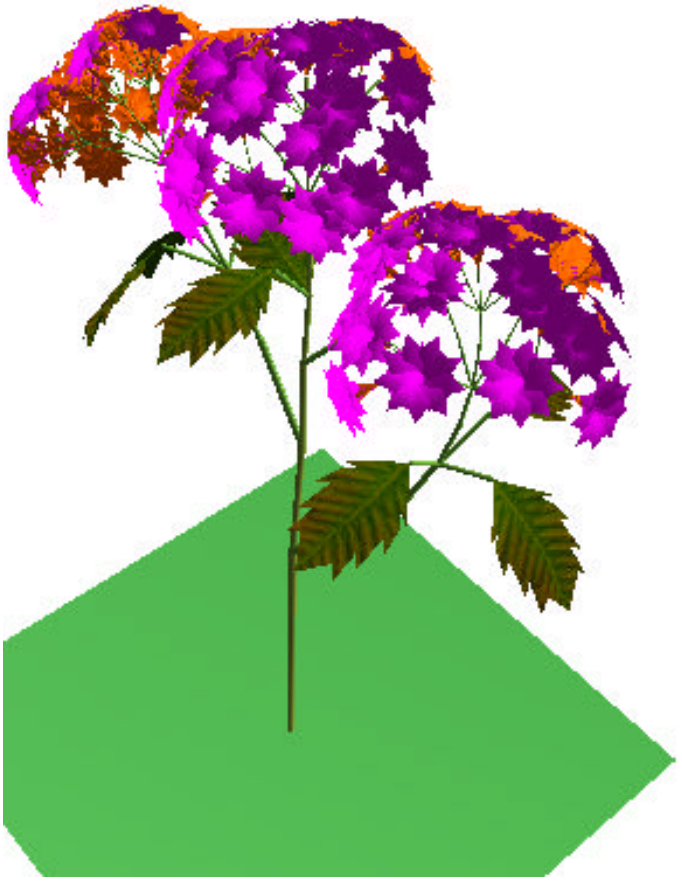

**Figure C-70: Change the flower and the leaf color.**

To exit the software, click the “Exit” button on the main menu as Figure C-71.


**Figure C-71: Exit the program.**