Effect of Soil Condition on the Root Contraction of Ginseng

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Abstract
Root contraction during 1 year after transplanting of Panax ginseng was investigated in relation to soil texture and watering under field conditions. Root longitudinal contraction (RLC, percent conservation of original length) occurred randomly along all longitudinal parts of the root in the investigation of 1 cm unit. Longitudinal contraction takes place in 5 different types and 48% for the downward acceleration type and 26% for the uniform type. RLC showed 2nd order polynomial regression with root weight or diameter. This relationship was significant in sandy loam soil regardless of watering and less in clayey loam soil. A threshold root weight having least RLC could be calculated from the regression equation with all roots and further utilized as an index for threshold soil condition. This investigation proved that ginseng root enlargement takes place in two ways after transplanting, cambial extension and longitudinal contraction.

INTRODUCTION
Korea Ginseng (Panax ginseng C.A. Meyer) has been known as king of herb medicine since Shen Nong Ben Cao Jing (Shen Nong Materia Medica, 2737~2698 BC), the oldest materia medica, in the East appeared. According to traditional quality criteria, the long and thick main body from the rhizome to the place where lateral roots begin is the most desirable for the internal quality of the root. Thus root shape that is determined by the balance of main body and lateral roots, is very important (Park et al., 1988). One of the most difficult tasks in improving the quality of ginseng is to establish the long main body of the root, because even these ginseng seedling roots, longer than 14 cm, tended to have a main root body length of 5 cm or shorter even after 5 years. It has been stated that ginseng would get into the earth gradually and finally disappear (Grushiviskii, 1963). For the study of root shape design we thought that there might be a key to make main body long in the above old legend. We investigated the root contraction during the first year of growth after transplanting.

MATERIALS AND METHODS
Soil condition: Permanent beds were made in a field of sandy loam soil at Ildong, Gyeonggi-do. Soil was mixed 20 cm of bed top with red soil (clay) by approximately 20% (V/V) to achieve a clayey loam soil composition.

Transplanting and Soil Moisture Management
Ban-yangjig seedlings were obtained from a commercial ginseng farm. Average seedling weight was 0.83 g (range 0.59~1.14 g), length 12 cm (9.5~14.5 cm) and diameter 4.73 mm (4.0~6.15 mm). Seedlings were marked with black lines 1cm apart on the root surface and transplanted according to method in March 2001. Three beds of each soil
texture were watered on the bed to maintain optimum soil moisture conditions and others remained without watering.

**Harvest**

Roots were harvested and 10 roots were selected in each plot from large roots for the investigation of root contraction in November 2001. Roots were washed and root diameter at the 2nd line was measured with calipers. Fresh root weight was measured. Statistical analysis of data was done by the Cricket program.

**RESULTS AND DISCUSSION**

**Contraction Position**

The shape of harvested roots is shown in Fig. 1. Black lines made with India ink was erased in the lower parts of many roots. Root contraction was measured along the root from the position just below the rhizome to the black line remaining. The pattern of positional contraction was grouped into 1) equal contraction (uniform contraction), 2) downward rapid, 3) upper rapid, 4) middle slow, and 5) zigzag, respectively. The frequency was 48% for the downward rapid type, 26% for uniform, 13% for upper rapid, 9% for middle slow and 4% for zigzag.

**Contraction and Weight**

Root weight and RLC of 10 selected roots from each treatment are shown in Table 1. While eleven roots did not contract in sandy loam soil only one root did not in clayey loam soil. Since non-contracted roots were all small roots the contraction seems to be related to the growth rate. There were significant differences between some treatments in mean value of each treatment weight or RLC by DMRT (Table 1).

RLC is the reverse of root length contraction. Mean root weight was greater in clayey loam than sandy loam soil, and greater in watered plot than in the control (natural condition).

Polynomial regression fitted better between root weight and RLC than did linear regression. The second order polynomial regression equation and coefficients in each treatment are as shown in Table 2. Significant relationship was shown only in sandy loam soil and watering increased significance of the relationship. In clayey soil the relationship was not significant but the tendency was reversed from negative in the control to positive in watered treatment due to the increased root weight (Fig. 2). Negative relation in the low range of weight and positive in the high range is seen in sandy loam soil.

Watering did not change the negative tendency in sandy soil but did change the tendency in clayey soil and indicates that watering was more effective in clayey loam. Relationship in all roots regardless of soil texture and watering is shown in Fig. 3.

The regression equation of all roots was significant (Fig. 3). This regression curve showed negative relation range and positive range along the root weight. From the regression curve the empirical minimum RCL (contraction maximum) of 69.12% could be obtained. The root weight at the minimum RCL was 3.77 g. This value can be used as an index for soil preparation and management for producing long main body in this soil. All kinds of cultivation techniques should be applied to make all roots obtain more than 3.77 g to minimize root contraction.

**Contraction and Diameter**

The regression between RLC and root diameter is shown in Fig. 4. Regression coefficient was significant (P=0.01) in sandy loam soil but not significant as it was in root weight because root weight showed a closer positive correlation with root diameter.

**CONCLUSIONS**

Our data indicated that contraction of ginseng root is not a mere legend but is real. After transplanting ginseng roots grow in two directions as the result of cambial extension
and longitudinal contraction. Root contraction rate was different along the root position, weight, diameter and soil composition. Cultivation practices for quality ginseng production can be established by methods of minimizing the longitudinal contraction and maximizing the root weight. For this purpose some effective indices could be obtained from regression equations between root contraction and root weight or diameter.

**ACKNOWLEDGEMENT**

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**Literature Cited**


Shen Nong, 2737~2698 BC, Shen Nong Ben Cao Jing (Shen Nong Materia Medica).

**Tables**

Table 1. Effects of soil texture and watering on ginseng root growth and contraction in the first year after transplanting.

<table>
<thead>
<tr>
<th>Watering &amp; Soil type</th>
<th>Root weight (g)(^z) order</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Control (non-watered)</td>
<td></td>
</tr>
<tr>
<td>SL^W W</td>
<td>2.84</td>
</tr>
<tr>
<td>RLC</td>
<td>90</td>
</tr>
<tr>
<td>CL^W W</td>
<td>2.25</td>
</tr>
<tr>
<td>RLC</td>
<td>83</td>
</tr>
<tr>
<td>Watered SL W</td>
<td>3.47</td>
</tr>
<tr>
<td>RLC</td>
<td>80</td>
</tr>
<tr>
<td>CL W</td>
<td>6.26</td>
</tr>
<tr>
<td>RLC</td>
<td>85</td>
</tr>
</tbody>
</table>

\(^z\)W: fresh weight g/root; RLC: contraction rate (percent remained to original length)

\(^y\)Values having the same letters are not significantly different by DMRT at p = 0.05

\(^*\)SL: sandy loam; CL: clayey loam soils, respectively
Table 2. Regression equation and coefficient between root weight and root length conservation in relation to soil texture and watering.

<table>
<thead>
<tr>
<th>Watering</th>
<th>Soil</th>
<th>a1x</th>
<th>a2x</th>
<th>b</th>
<th>R^2</th>
<th>df</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>SL</td>
<td>8.253</td>
<td>-32.998</td>
<td>115.36</td>
<td>0.6742**</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>CL</td>
<td>-5.023</td>
<td>10.639</td>
<td>83.85</td>
<td>0.1066</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>7.873</td>
<td>-31.204</td>
<td>113.45</td>
<td>0.4839***</td>
<td>18</td>
</tr>
<tr>
<td>Watering</td>
<td>SL</td>
<td>5.825</td>
<td>-34.239</td>
<td>127.36</td>
<td>0.7936***</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>CL</td>
<td>0.303</td>
<td>-1.789</td>
<td>85.61</td>
<td>0.0859</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2.137</td>
<td>-16.537</td>
<td>110.57</td>
<td>0.5898***</td>
<td>18</td>
</tr>
<tr>
<td>Total</td>
<td>SL</td>
<td>2.665</td>
<td>-18.046</td>
<td>109.97</td>
<td>0.6627***</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>CL</td>
<td>0.871</td>
<td>6.604</td>
<td>94.63</td>
<td>0.2283*</td>
<td>18</td>
</tr>
<tr>
<td>Grand</td>
<td>Total</td>
<td>1.732</td>
<td>-13.078</td>
<td>104.21</td>
<td>0.5120***</td>
<td>38</td>
</tr>
<tr>
<td>Mean</td>
<td>Total</td>
<td>1.292</td>
<td>-9.390</td>
<td>100.8</td>
<td>0.7421</td>
<td>2</td>
</tr>
</tbody>
</table>

* SL: sandy loam and CL: clayey loam  
***, **, *: significant at 0.001, 0.01, 0.05

**Figures**

Fig. 1. Effects of soil texture on root growth and contraction of ginseng with watering in soils having different texture (left: clayey loam, right: sandy loam soil).
Fig. 2. Relationship between RLC and root weight in relation to soil texture and watering.

Fig. 3. Relationship between RLC and root weight regardless of soil condition and watering.
Fig. 4. Relationship between RLC and root diameter in relation to soil texture with watering.