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Regional Comparison of Physiochemical Properties of *Codonopsis lanceolata*

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ABSTRACT This study was conducted to compare the growth, inorganic components, and proximate components of *Codonopsis lanceolata* grown in 10 regions of Korea for selecting superior species and breeding by crossing. Among the all tested lines, the shortest plant height (217.12 cm) was observed from the Ulleungdo region line (No. 4) while the longest (273.9 cm) was observed from Hwasun region line (No. 9). In addition, the lines of central and northern region (No. 1 ~No. 7) tend to have shorter plant height than those of southern region (No. 8~No. 9) except Jejudo region line (No. 10). Flowering tends to be late towards southern region, and lines in central and northern regions were started flowering about 2 weeks earlier than those in southern regions. However, the heaviest root weight was 13.1 g, found in only Jejudo line (No. 10) whereas there was no significant difference found in the other regions which have a range of 8.3~11.0 g. The inorganic components were varied in each line, however, proportion of macroelements, such as K, Ca, and P, was the largest for every line. Especially for Heongseong region line (No. 2), had larger proportion of macroelements than the others. There was a difference of proximate compositions of Codonopsis lanceolata, except the moisture content, among all regions, however, it was generally shown that the content of crude protein (1.31~3.76%) and crude fiber (2.18~3.12%) was the highest.

Keywords : growth characteristics, inorganic components, proximate components, *Codonopsis lanceolata*

The *Codonopsis lanceolata*, which belongs to the Campanulaceae, is the perennial vine plant, grown naturally in half shade of mountains in the countries such as Korea, Japan, and China. Most *Codonopsis lanceolata* are so acclimated and cultivated from the wild species that are commercialized by superior species. *Although Codonopsis lanceolata* is profitable and the cultivating area has been increased every year, distribution of superior species is virtually not made.

Codonopsis lanceolata are differentiated by their habitats that is well known as the plant type, root type, color tone, and lateral root type (Lee *et al*., 1996). Moreover, not only the appearances but also the active components and inorganic components of the root are varied by their growing area, therefore, the planting area is being specified (Lee *et al*., 1991). Even though in the same growing area, the components of the root are differed by natural and cultivating lines (Kim, 1985; Lee, 1984).

The *Codonopsis lanceolata* is used for a healthy Korean dishes as well as medicine, and cultivated from various regions of Korea. However, active improvement of the species through breeding programs such as selective breeding, cross-breeding is not applied yet. Therefore, this study was executed to investigate and compare the growth, inorganic components, and proximate components of *Codonopsis lanceolata* grown in 10 regions of Korea for selecting superior species and breeding by crossing.

MATERIALS & METHODS

The seeds of *Codonopsis lanceolata* were collected from 10 regions of Korea (Fig. 1) on October, 2013. The seeds were sown on vermiculite and sprouted in non-heating vinyl greenhouse in

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Fig. 1. Sample collection sites of *Codonopsis lanceolata* accessions in Korea 1. Hwacheon, 2. Heongseong, 3. Jecheon, 4. Ulleungdo, 5. Uljin, 6. Yesan, 7. Sangju, 8. Muju, 9. Hwasun, 10. Jejudo.

Woosong Information College on 20th April, 2014. At the time of observing a foliage leaf on 18th May, the seedlings are planted separately in 15cm diameter vinyl pot, filled with mixture, composed of one part of vermiculite to one of horticultural nursery soil. As of appearing more than or equal to two foliage leaves, the growth characteristics, such as plant height, leaf width, leaf length, and numbers of branches, was examined with an interval of 15 days. At the same year on of 17th October, the plants were harvested and measured root length, root width, fresh weight, and so forth. Moreover, inorganic component and proximate composition, contained in the root of *Codonopsis lanceolata* for each region, were also analyzed.

Analysis of inorganic components

Sample was incinerated at 600℃ for 12 hours and then decomposed by wet combustion method (Woo and Ryoo, 1983) and then made its quantity fixed with deionized distilled water to test the liquid. After adding 10 ml of thick nitric acid to 2 g of roots of *Codonopsis lanceolata* for each region, the solution was heated with low temperature at first and then gradually increased heating temperature to decompose it. Decomposed solution was chilled when the solution become white and transparent, and then added distilled water to the solution and made its quantity fixed to 100 ml, and then filtered it to make the remained liquid as the sample. The quantity of each mineral content was examined by ICP (Inductively Coupled Plasma, 3300DV, PerkinElmer Optima, USA). The condition of analysis was was maintained in the following plasma 15 l/min for the gas flow rate, 0.5 l/min for the auxiliary, 0.8 l/min for the nebulizer, 1,300 watts for the RF power, 1.0 ml/min for the flow rate, 18.48 rpm for the speed, 1.0 ml/min for the sample flow rate, 30sec for the sample flush time, 4.0 ml/min for the sample flush rate, and 30sec for the delay time (Jung *et al*., 2012).

Analysis of proximate compositions

The general components of the sample were analyzed by AOAC method (AOAC, 1990). Moisture was analyzed by ambient drying at 105℃ and the ash contents were examined by dry ashing method. Crude protein contents were measured by Kjeltec protein analyzer (Tecator, Sweden) with using micro-Kjeldahl method, and crude fat contents were analyzed by Soxhlet method.

Statistical analysis

Using SAS program (SAS, 9.2, Institute Inc, USA), statistical analysis was conducted by Duncan's multiple range test (p=0.05).

RESULTS & DISCUSSION

Growth and yield of *Codonopsis lanceolata* in 10 regions

The characteristic of the growth of *Codonopsis lanceolata*, collected and cultivated in 10 regions of Korea, was shown in Table 1. The shortest plant height (217.12 cm) was observed from the Ulleungdo region line (No. 4) and the longest (273.9 cm) was observed from Hwasun region line (No. 9) among every line being tested. Every line has more than 200cm of its plant height and there were no dwarf plants which don't need the support. In addition, the lines of central and northern region (No. 1~No. 7) tend to have shorter plant height than those of southern region (No. 8~No. 9) except Jejudo region line (No. 10). Kim (2003) suggested that the number of leaves and plant height for each *Codonopsis lanceolata* were highly correlated with its cultivating region, however, no significant difference, except the Hwasun region line, was found among the *Codonopsis lanceolata*

Table 1. Comparison of growth characteristics of *Codonpsis lanceolata* accessions collected in Korea.

Accession	Plant height (cm)	Leaf width (cm)	Leaf length (cm)	No. of branches	Flowering day
1. Hwacheon	242.3abc[z]	4.4cde	6.7de	16.1a	Aug. 4
2. Heongseong	252.6ab	4.1bc	6.7de	23.3b	Aug. 5
3. Jecheon	237.9abc	4.4cde	6.6cde	21.3b	Aug. 9
4. Ulleungdo	217.1a	4.1bc	6.6cde	22.2b	Aug. 6
5. Uljin	240.3abc	4.1bc	6.9e	21.5b	Aug. 8
6. Yesan	231.2ab	4.8e	6.4cd	22.1b	Aug. 10
7. Sangju	238.6abc	4.4cde	5.8b	22.5b	Aug. 10
8. Muju	258.3bc	3.9b	5.9b	21.7b	Aug. 18
9. Hwasun	273.9c	4.3bcd	6.3bc	22.8b	Aug. 20
10. Jejudo	226.2ab	3.4a	4.9a	23.9b	Aug. 24

[z]Values followed by common letters in the same column are not significantly different(P=0.05, Duncan's multiple range test).

lines in this study.

Aboveground parts were divided to 3 parts—upper part (above 120 cm), middle part (60~120 cm), and lower part (from ground to 60 cm), and 3 leaves were examined from each part. As a result, the longest leaf width and leaf length were found both in Yesan region line (No. 6) and Uljin region line (No. 5) of 4.8 cm and 6.9 cm respectively. The shortest was found in Jejudo region line (No. 10) of 3.4 cm and 4.9 cm respectively. There was no significant difference found regarding leaf width and leaf length in other lines, which have a range of 3.9~4.4 cm and 5.8~6.7 cm respectively, in addition, there was no correlation with each region found.

The number of branches, which have more than or equal to 5 cm of the length, was 16.1 in Hwacheon region line (No. 1), however, there were no differences between lines and correlation with the region found in the rest, which have a range of 21.3~23.9.

Flowering was initiated from early August. The first flowering was on 4th August, found in Hwacheon region line (No.1), and the last flowering was on 24th August, found in Jejudo line (No. 10), so there was about 20 days interval between them (Table 1). In other words, flowering tends to be late towards southern region, and lines in central and northern regions were started flowering about 2 weeks earlier than those in southern regions.

It was reported that flowering of central and southern region lines was about 10 days earlier than that of southern region lines (Lee *et al*., 1996). In comparisons of flowering day between Korean lines (Baegunsan line) and Japanese lines (Hachioji line), no significant difference was found between the two lines however, Japanese lines were flowered slightly faster (Kim, 1993). Likewise, in this study, it was confirmed that the flowering day of central and northern region lines was faster than that of southern region lines.

The characteristics of the root of *Codonopsis lanceolata* in 10 regions of Korea, were shown in Table 2. The longest length of main root part, grown to big, was 8.6 cm, found in Muju region line (No. 8), and the shortest was found in Jejudo line (No. 10). The rest regions have a range of 7.5~8.0 cm, so there were no significant differences between each line and region. The finest

Table 2. Comparison of root characteristics of *Codonpsis lanceolata* accessions collected in Korea at harvest.

Accession	Length (cm)	Diameter (mm)	Fresh weight (g)
1. Hwacheon	7.7ab[z]	13.8a	8.3a
2. Heongseong	8.0ab	15.8bcd	8.9a
3. Jecheon	7.8ab	15.8bcd	10.1ab
4. Ulleungdo	7.9ab	14.3abc	9.0a
5. Uljin	7.6ab	15.6bcd	9.7a
6. Yesan	7.8ab	16.4cd	8.8a
7. Sangju	7.5ab	15.8bcd	8.7a
8. Muju	8.6b	15.3bcd	11.0ab
9. Hwasun	7.5ab	16.1cd	8.6a
10. Jejudo	7.1a	18.7d	13.1b

[z]Values followed by common letters in the same column are not significantly different(P=0.05, Duncan's multiple range test).

root diameter was 13.8 mm, found in Hwacheon region line (No. 1), however, there were no significant differences found in the rest lines. The highest root weight was 13.1 g, found in Jejudo line (No. 10), however, there were no significant differences found in the rest lines which have a range of 8.3~11.0 g (Table 2).

Analysis of the inorganic components of *Codonopsis lanceolata* in 10 Regions

The inorganic components of *Codonopsis lanceolata*, collected and cultivated in 10 regions of Korea, were shown in Table 3. The inorganic components were varied by each line, however, proportion of macroelements, such as K, Ca, and P, was the largest for every line. Especially for Heongseong region line (No. 2), had larger proportion of macroelements than the others. The highest contents of Ca was found in Uljin region line (No. 5) by 3000 ppm and those of P was found in Heongseong region line (No. 2) by 5599 ppm. In terms of microelements, the highest proportion of Fe was found in Uljin region line (No. 5) and Jejudo line (No. 10) by 550.5 ppm and 507.4 ppm respectively. The rest region lines had higher content of Fe than that of other microelements. Hwacheon region line (No. 1) and Jecheon region line (No. 3) did not contain any Co, however, the rest regions had a trace of Co. Every line had a trace of Ni, and a tiny proportion of Pb was found in Uljin region line (No. 5) and Yesan region line (No. 6), however, the rest regions had not Pb at all (Table 3).

As a result of this study, it is confirmed that difference of inorganic components between each region, therefore, it conforms to the prior studies—differences of inorganic components was found for each cultivating region (Lee *et al*., 1995) and similar phenomenon was found in ginseng (Ko *et al*., 1996). Nevertheless, further study is thought to be needed to figure out whether such results were drawn by the environments of growth, such as habitat specific environment for each region or specific soil conditions.

Analysis of the proximate compositions of *Codonopsis lanceolata* in 10 regions

The proximate compositions of the root of *Codonopsis lanceolata,* collected and cultivated in 10 regions of Korea, was shown in Table 4. There was a difference of proximate compositions of *Codonopsis lanceolata*, except the moisture content, between each region, however, it was generally shown that the content of crude protein (1.31~3.76%) and crude fiber (2.18~3.12%) was the highest. Moisture content was 85.98% in Jejudo region line (No. 10), slightly higher than other regions, however, significant difference was not shown in the rest with the range of 76.69~82.14%. The lowest content of crude protein was 1.31%, found in Ulleungdo region (No. 4), and the highest content of that was 3.76%, found in Muju region line (No. 8). There was no significant difference of the crude fat content for each region with a range of 0.33~0.50%, however, it tended to be lower towards southern regions. In terms of crude fiber, the content was more than 3% in Heongseong region line (No. 2) and Uljin region line (No. 5), and the southern regions had lower content compared to northern regions. There was not significant difference of crude

Table 3. Comparison of inorganic components contained in the *Codonpsis lanceolata* roots collected in Korea.

Accession[z]	Inorganic elements (ppm)												
	Na	Mg	P	S	K	Ca	Mn	Fe	Co	Ni	Cu	Zn	Pb
1. Hwacheon	35.67	793.9	1354	0.926	6566	1014	11.34	281.4	0	0.199	2.37	7.353	0
2. Hoengseong	203.7	2045	5599	3.538	14512	1786	26.3	114.6	0.027	1.287	8.574	20.91	0
3. Jecheon	37.44	1013	1731	1.64	6122	1157	15.48	104.2	0	0.276	2.129	12.21	0
4. Ulleungdo	61.22	1547	838.2	2.44	11361	2201	29.83	180.8	0.229	0.272	4.762	12.15	0
5. Uljin	154.5	1195	377.8	2.291	13780	3000	52.31	550.5	1.244	0.706	5.196	18.08	1.347
6. Yesan	36.8	1010	1512	2.679	5477	1446	8.557	154.2	0.034	0.644	4.519	19.06	0.356
7. Sangju	24.34	1214	2002	2.117	11376	1768	15.72	210.5	0.095	0.640	7.507	17.96	0
8. Muju	165.5	762.8	2533	1.513	10466	1420	38.93	207.3	0.224	1.526	5.421	18.63	0
9. Hwasun	77.53	1315	2145	1.633	7009	1496	16.93	155.7	0.028	0.028	4.028	12.66	0
10. Jejudo	91.17	1158	868.3	2.16	8600	1611	63.92	507.4	1.188	1.7	7.321	21.86	0

[z]Values followed by common letters in the same column are not significantly different(P=0.05, Duncan's multiple range test).

Table 4. Comparison of proximate composition of *Codonpsis lanceolata* accessions collected in Korea.

Accession	General nutrients (%)				
	Moisture	Crude protein	Crude fat	Crude fiber	Crude ash
1. Hwacheon	81.89	2.55	0.42	2.51	0.99
2. Heongseong	76.69	2.49	0.50	3.07	1.38
3. Jecheon	78.66	1.64	0.41	2.55	0.93
4. Ulleungdo	82.14	1.31	0.37	2.72	1.01
5. Uljin	81.89	1.65	0.44	3.12	0.96
6. Yesan	77.72	2.93	0.46	2.55	1.11
7. Sangju	83.84	2.51	0.39	2.79	0.89
8. Muju	81.69	3.76	0.33	2.22	1.01
9. Hwasun	77.12	1.68	0.33	2.38	0.74
10. Chejudo	85.98	2.25	0.36	2.18	1.29

ash content between each region with a range of 0.74~1.38% and tendency by each region was also not found (Table 4). Significant difference of the proximate compositions of *Codonopsis lanceolata* was not found for each cultivating or growing region (Lee, 1984), and proximate compositions by the temperature of growth were found to be the highest at 30℃ (Lee *et al*., 1992). According to the results of this study, the content of crude protein and crude fiber in *Codonopsis lanceolata* root was differed by each region, moreover, contrary result was shown that significant increase of proximate compositions was not found in southern regions, which have higher average temperature.

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