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인삼의 재식위치와 생육시기에 따른 생육특성 및 진세노사이드 함량 변화

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Changes of Growth Characteristics and Ginsenoside Content by Growth Stages and Different Planting Position in *Panax ginseng* C.A. Meyer

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ABSTRACT : This study was conducted to investigate the effect of planting position on the growth characteristics, yield and ginsenoside content in *Panax ginseng* C.A. Meyer at different growth stages. Referring to shoot growth characteristics, stem length, stem diameter and leave area were higher at front than rear, increasing as the proceeding of growth stages. But a lower chlorophyll contents was caused at front compared to rear and decreased as the proceeding of growth stages contrarily. According to root characteristics, root length and main body length were higher at front, with a positive correlation to growth stages, which was also shown on fresh root weight and dry root weight with the maximum in August. Meanwhile, the effect of planting position on ginsenoside content could also be definite by the highest content at front showing high light intensity, increasing as the proceeding of growth stages as well.

Key Words **:** *Panax ginseng,* Planting Positions, Growth Stages, Root, Ginsenoside

INTRODUCTION

As a cool-season plant preferred to low temperature and light, *Panax ginseng* C.A. Meyer were cultivated in the inclined shading installation with high front and low rear. So, the difference of ginseng growth environment came out according to the different planting positions (Kim *et al*., 1982; Lee *et al*., 1980, 1982; Park *et al*., 1979) because the influent light intensities were different by this inclined structure (Kim *et al*., 1982; Lee *et al*., 1987). Especially, light saturation point of ginseng leave commonly increased to 22,000 lux in low temperature such as 15℃, as reported before, and the optimum light of photosynthetic rate changed as the different temperatures by 11,000 lux at 20℃ and 9,500 lux at 25℃ as the optimum level, which also different among growth stages (Lee *et al*., 1982; Jo *et al*., 1985). Leaves photosynthesis cultivated at different light condition were different (Lee *et al*., 1982) because light saturation point of leaves cultivated at front showing high light was 10,000 lux but that at rear was 4,000 lux. Thus, we considered that ginsenoside as the important pharmacological ingredient would also be affected as well by the different light condition. Meanwhile, ginsenoside content fluctuated strikingly according to the different climatic and cultivating environment (Kim *et al*., 2009; Lee *et al*., 2009; Lee *et al*., 2007; Lee *et al*., 1987) and growth stages (Choi *et al*., 2009). Therefore, this study was practiced to investigate the characteristics of growth and ginsenoside content according to different planting positions at different growth stages.

MATERIALS AND METHODS

1. Variety and Cultivation

one-year-old domestic variety of *Panax ginseng* obtained from ginseng elite farmers were cultivated at Pusan National University's farmland (Bubukmyeon in Miryang city) in 2008. Decomposed compost (grass 70% + sawdust 20% +

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manure10%) was completely manured by 2,000 kg/10a and manufactured the furrows and ridges (height 25 ㎝, width 90 ㎝) after mixing by rotary. Ginseng seedlings were planted at 15 ㎝ distance by ginseng transplanter, followed by covering over bed soil with rice straw to prevent from weeds and water evaporation. Ginseng administrative standard established by Rural Development Administration was followed as well.

2. Shade material and plant density

Shade material was adopted to silver-coated shade plate by near-line form with front height at 180 ㎝ and rear height at 100 ㎝. Planting density was 54 seedlings (6 lines × 9 rows) every experiment plot (180 × 180 ㎝).

3. Investigation of growth characteristics

Three-year-old ginseng growing normally was sampled in June, July and August to investigate the growth characteristics of shoot and root, respectively. Leave area by area determinator LI-3100, Chlorophyll content as SPAD value by SPAD 502 (Minolta) for 3 times. Stem length from rhizome top to petiole bottom, and stem width at the widest part of stem were measured by vernier caliper. According to root characteristics, root length from rhizome bottom to the end of root, and main body length from rhizome bottom to the beginning of supporting root, and root diameter at the widest part of main body by vernier caliper, were measured too. Fresh weight was measured after ginseng washed and dried with absorbent paper without peeling, followed by dry weight measure after drying for 7days at 50.

4. Ginsenoside analysis

High Performance liquid chromatography (HPLC) with Perkin elmer series 200 Pump, Peltier column oven, UV/VIS Detector, Vacuum Degasser, Column by ZORBAX Eclipse XDB-C18 (4.6 × 150 ㎜, 5 ㎛) was linked to Series 600 LINK. All of the reagents such as H_2O, CH_3CN, CH_3OH were Burdick & Jackson products of SK Chemical (HPLC grade) and the standard used in HPLC analysis were products of Sigma (USA) and Extrasynthese (France). Samples after growth characteristics investigation were dried to crush into powder, recirculation cooling in 70% methanol, separating by Di-ethylether and 1-butanol, measuring by HPLC.

RESULTS AND DISCUSSION

1. Growth characteristics of shoot by planting positions at different growth stages

Referring to Table 1. as growth characteristics of shoot by planting positions at different growth stages, stem length were longer at front to center and rear by 25.5 ㎝, 27.2 ㎝ and 27.9 ㎝ at growth beginning in June, July, and August, respectively and stem diameter were 4.9 ㎜, 5.0 ㎜, and 5.0 ㎜ at front in different growth stages, which were thicker than that at center and rear. According to Cheon *et al.*, (1991), stem length and stem diameter of 2-year-old and 4-year-old ginseng were decreased as PAR decreasing, meanwhile, we found the report in Choi *et al.*, (1980) that stem length and stem diameter of 3-year-old ginseng was fine at center, different to our result that those were better at front with higher PAR, which is considered to be caused by the lower temperature and higher PAR by silver-coated shading plate compared to polyethylene shade net (Lee *et al.*, 2007), so it is better to ginseng growth at front with higher PAR. Leave area were also larger at front by 322 ㎠, 345 ㎠, and 355 ㎠ at different growth stages.

Table 1. Growth characteristics of shoot by planting positions at different growth stages.

Month	Stem length (㎝)			Stem diameter (㎜)			Leaf area (㎠/plant)			SPAD value		
	F†	C	R	F	C	R	F	C	R	F	C	R
June 8	25.5a (100)	22.8a (100)	21.9a (100)	4.9a (100)	4.8a (100)	4.2a (100)	322a (100)	312a (100)	302a (100)	35.1b (100)	36.2b (100)	41.1b* (100)
July 6	27.2b (106.7)	26.8b (117.5)	25.7b (117.4)	5.0a (102.0)	4.8a (100.0)	4.5b (107.1)	345b (107.2)	340b (109.1)	321b (106.3)	33.5ab (95.4)	37.1ab (102.5)	39.9b (97.1)
Aug 10	27.9b (109.4)	27.6b (121.1)	26.9c (122.8)	5.0a (102.0)	4.9a (102.1)	4.4b (104.8)	355b (110.2)	344b (110.5)	343c (113.7)	30.3a (86.3)	34.4a (95.0)	36.8a (89.5)

*Mean with same letters are not significantly different in DMRT ($p < 0.05$)
†F: front, C: center, R: rear

Table 2. Growth characteristics of root by planting positions at different growth stages.

Month	Root length (㎝)			Root trunk (㎝)			Root diameter (㎜)		
	F†	C	R	F	C	R	F	C	R
June 8	24.0a (100)	23.0a (100)	20.8a (100)	10.2a (100)	10.0a (100)	9.3a (100)	12.4a (100)	12.1a (100)	12.5a* (100)
July 6	25.2b (105.0)	24.8b (107.8)	24.1b (115.9)	11.5b (112.7)	10.6b (106.0)	9.6b (103.2)	14.3b (115.3)	13.3b (109.9)	13.9b (111.2)
Aug 10	27.1c (112.9)	26.7c (116.1)	26.4c (126.9)	11.4b (111.8)	10.9b (109.0)	11.5c (123.7)	16.6c (133.9)	15.7c (129.8)	15.1c (120.8)

*Mean with same letters are not significantly different in DMRT ($p < 0.05$)
†F: front, C: center, R: rear

Table 3. Root weight by planting positions at different growth stages.

Month	Root weight (g)			Dry root weight (g)		
	F†	C	R	F	C	R
June 8	9.9a (100)	8.9a (100)	8.2a (100)	3.0a (100)	2.7a (100)	2.6a* (100)
July 6	14.2b (143.4)	11.4b (128.1)	11.8b (143.9)	3.5b (116.7)	3.2b (118.5)	3.3b (126.9)
Aug 10	18.1c (182.8)	16.0c (179.8)	15.9c (193.9)	4.8c (160.0)	4.0c (148.1)	4.0c (153.8)

*Mean with same letters are not significantly different in DMRT ($p < 0.05$)
†F: front, C: center, R: rear

Table 4. Ginsenoside characteristics by planting positions at different growth stages.

Month	Line	Rb1	Rb2	Rb3	Rc	Rd	Re	Rf	Rg1	Rg2	Rg3	Rh1	Rh2	Total
June 8	F†	0.23a	0.05b	0.01a	0.11a	0.06a	0.27a	0.10a	0.34a	0.03a	0.04a	0.01	–	1.25a*
	C	0.17b	0.13a	0.02a	0.15a	0.08a	0.25a	0.05a	0.20b	0.01a	0.01a	–	–	1.07b
	R	0.16b	0.09a	0.01a	0.11a	0.07a	0.28a	0.05a	0.17b	0.02a	0.02a	–	–	0.98b
July 6	F	0.24a	0.13a	0.02a	0.16b	0.10a	0.21b	0.11a	0.39a	0.04a	0.06a	0.01	–	1.47a
	C	0.25a	0.17a	0.02a	0.28a	0.14a	0.32a	0.08a	0.21b	0.03a	0.01a	–	–	1.51a
	R	0.21a	0.11a	0.02a	0.17b	0.12a	0.27ab	0.08a	0.24b	0.03a	0.04a	–	0.01	1.30b
Aug 10	F	0.36a	0.17a	0.03a	0.17b	0.25a	0.40a	0.15a	0.50a	0.04a	0.08a	0.01	–	2.16a
	C	0.27b	0.21a	0.03a	0.24a	0.15b	0.38a	0.09a	0.29b	0.03a	0.06a	–	–	1.75b
	R	0.25b	0.16a	0.02a	0.18b	0.21a	0.42a	0.08a	0.25b	0.03a	0.07a	–	0.01	1.68b

*Mean with same letters are not significantly different in DMRT ($p < 0.05$)
†F: front, C: center, R: rear

SPAD value were 35.1, 36.2, and 41.1 in June, 33.5, 37.1, and 39.9 in July, 30.3, 34.4, and 36.8 in August at front, center and rear, respectively, which was corresponding to that SPAD value decreased when light intensity increased (Jo *et al.*, 1986; Park *et al.*, 1987). This result was similar to that of our study.

2. Growth characteristics of root by planting positions at different growth stages

As growth characteristics of root by planting positions at different growth stages, root length were longer at front to center and rear by 24.0 ㎝, 25.2 ㎝ and 27.1 ㎝ at growth beginning in June, July, and August, respectively and root diameter were 12.4 ㎜, 14.3 ㎜, and 16.6 ㎜ at front in different growth stages, which were thicker than that at center and rear. It was almost the same with growth characteristics of shoot that those was better at front than those at rear. Also, referring to Table 3, fresh root weight were shown that front > center > rear by 9.9 g, 14.2 g, and 18.1 g at front in different growth stages, same to dry root

Table 5. PD/PT ratio of ginsenoside by planting positions at different growth stages.

Month	Line	PD	PT	PD/PT
June 8	F†	0.50ab	0.75a	0.67c*
	C	0.56a	0.51b	1.10a
	R	0.46b	0.52b	0.88b
July 6	F	0.71b	0.76a	0.93c
	C	0.87a	0.64b	1.35a
	R	0.68b	0.62b	1.10b
Aug 10	F	1.06a	1.10a	0.96b
	C	0.96a	0.79b	1.22a
	R	0.90a	0.78b	1.15ab

*Mean with same letters are not significantly different in DMRT ($p < 0.05$)
†F: front, C: center, R: rear

weight, which was also reported by Choi *et al.,* (1980) and Lee *et al.*, (1983) that root weight was increased at front position.

3. Ginsenoside characteristics of root by planting positions at different growth stages

Ginsenoside characteristics of root by planting positions at different growth stages as Table 4 showed that the total content increased as growth stages proceeding by were 1.25%, 1.07%, and 0.98% in June, 1.47%, 1.51%, and 1.30% in July, 2.16%, 1.75%, and 1.68% in August at front, center and rear, respectively. Ginsenoside content changed by harvest times (An *et al*., 2002) and it also showed difference by a variety of light intensity (Lee *et al*., 1983; Cheon *et al*., 1991). In this study, ginsenoside content were changed according to different planting positions in which inflowed light were different as well. PD/PT rate at front, center, and rear were 0.67, 1.10, and 0.88 in June, 0.93, 1.35, and 1.10 in July and 0.96, 1.22, and 1.15 in August, respectively, which revealed the same tendency with that PD/PT rate was lower in high light intensity (Cheon *et al*., 1991).

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