

Comparison of Growth Characteristics and Quality of Ginseng (*Panax ginseng* C. A. Meyer) Grown under Upland and Paddy Field

Sung Woo Lee, Seung Won Kang, Nak Sul Seong, Geun Su Hyun,
Dong Yun Hyun, Young Chang Kim, and Seon Woo Cha[†]

National Institute of Crop Science, RDA, Suwon 441-857, Korea

ABSTRACT: This study was carried out to investigate the difference of growth characteristics, yield and extract content between upland and paddy ginseng cultured with 4-year-old ginseng in 2003. Although upland ginseng showed larger variation in yield than that of paddy ginseng, the average of it was greater than that of paddy ginseng because it showed better growth of aerial part and higher survival rate than that of paddy ginseng. Moisture content of fresh root was 71.8% (68.5 ~ 73.1%), and 72.7% (70.2 ~ 74.9%) on average in upland and paddy ginseng, respectively. Paddy ginseng showed higher hardness in taproot, and higher rate of rusty colored root than that of upland ginseng. The ratio of taproot dry weight in upland ginseng was smaller than that of paddy ginseng, while that of lateral root was larger in upland ginseng. Ratio of marketable root (>60 g) to total harvested roots was 13.7% (0.82 ~ 8.0%) and 7.7% (1.6 ~ 12.6%) in upland and paddy ginseng, respectively. Extract content did not show distinct difference between upland and paddy ginseng, but it showed large variation from 16.1 to 25.1% in taproot, and from 24.2 to 32.5% in lateral root depending on the ginseng field examined.

Keywords: *Panax ginseng*, paddy ginseng, upland ginseng, growth characteristics, dry weight, ethanol extract

Ginseng (*Panax ginseng* C. A. Meyer) has mainly been cultured in upland-soil field from old times, but nowadays ginseng cultivation using paddy-soil field has been increasing gradually for overcoming the injury induced by successive cropping because it is possible to practice sequential cropping in field where rice was cultured for 4 ~ 5 years after harvesting ginseng. Jo *et al.* (1996) reported that ginseng scarcely showed the injury of successive cropping in paddy-soil field where rice was cultured for 4 years due to soil condition such as flooding irrigation, and there were no significant differences in yield, saponin content, and ginsenoside composition in ginseng cultivated by upland-soil and paddy-soil field. Lee *et al.* (1995) reported that silty clay loam was mostly occupied by 74.1% in paddy-soil field

for cultivating 6-year-old ginseng at the northern part of Gyeonggi province, while loam and sandy loam was occupied by 43.2% and 56.8%, respectively, in paddy-soil field for cultivating 4-year-old ginseng at the southern part of the Korea such as Umsung, Kumsan, and Punggi. Lee *et al.* (1995) also reported that silty clay loam showed highest yield, but sandy loam showed lowest yield in paddy-soil field of 6-year-old ginseng. However, there are little information related to the yield and quality according to soil texture of upland-soil and paddy-soil field. Environmental factor that mainly affected on yield was soil moisture content, and soil organic matter played an important role in preserving soil moisture (Park *et al.*, 1982), and soil moisture distinctly affected the growth of ginseng regardless of the kinds of soil texture (Mok *et al.*, 1981; Nam *et al.*, 1980). Meanwhile, extract content of ginseng was different by harvest time (Kim, 1986), and it was changed by extracting conditions such as polarity and concentration of solvent (Jang *et al.*, 1987; Kim *et al.*, 1987; Sung *et al.*, 1985). However, it is necessary to study the changes of growth characteristics and extract content by the difference of cultural condition such as upland and paddy ginseng. Therefore, the object of this study was to obtain basic information for the improvement of yield and quality by means of investigating growth characteristics and quality of ginseng cultured in upland-soil and paddy-soil field

MATERIALS AND METHODS

Fifteen fields selected at ginseng-producing region of Kumsan, Punggi, Umsung, and Ansong were divided into two categories of upland and paddy ginseng by means of different soil condition such as upland and paddy-soil field. The number of field investigated was 8 and 7 of upland and paddy ginseng, respectively, and this experiment was carried out from April to October, 2003. Variety examined in this experiment was Jakyeongjong (*Panax ginseng*), a Korean landrace of 4-year-old ginseng. Although recommended cultural practices were followed, there were little difference in plant density, shade material, light transmission ratio and other cultural management according to investigated field.

[†]Corresponding author: (Phone) +82-31-290-6817 (E-mail) leesw@rda.go.kr

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Table 1. Comparison of soil physical properties at upland and paddy-soil field.

Treat.		Bulk density (g/cm ³)	Air phase (%)	Solid phase (%)	Liquid phase (%)	Porosity (%)
Upland	Aver.	1.2 ± 4 0.1	39.3 ± 3 9	46.4 ± 4.0	14.3 ± 2.4	53 6 ± 4.0
	C. V.	8 2	9.9	8 7	17 1	7.5
	Range	1 08~1 39	34.4~44.2	40.95~2.3	11 1~18.1	47.7~59.1
Paddy	Aver.	1.15 ± 0.1	40.0 ± 3.2	43 3 ± 3 9	16.7 ± 1.9	56 7 ± 3.9
	C. V.	8 8	8.1	8.9	11.5	6.8
	Range	1.01~1.26	36.4~46.3	38.1~47 7	14.7~19.8	52 3~61.9

† Investigation date: April, June, August, and October by one times per month

‡ No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively.

Table 2. Comparison of soil chemical properties at upland and paddy-soil field

Treat		pH (1 5)	OM (g/kg)	P ₂ O ₅ (mg/kg)	Ex.Cation(cmol/kg ⁻¹)			EC (ds/m)
					K	Ca	Mg	
Upland	Aver	5 2 ± 0.8	21 ± 12.8	266 ± 179	0 51 ± 0 32	5.34 ± 2.28	1.78 ± 0.90	0.70 ± 0.62
	C. V.	16.3	60.1	67.4	64.0	42 7	50 4	88.1
	Range	4.0~6.8	8~45	58~567	0 09~0 59	1.10~7.60	0 70~2.70	0 19~2 12
Paddy	Aver.	5.1 ± 0.2	16 ± 6.3	282 ± 288	0.38 ± 0.32	4.77 ± 1.73	1.27 ± 0.49	0.53 ± 0.37
	C. V	4.6	40.0	102 4	85.1	36 2	38 3	69 2
	Range	4 7~5.4	7~26	40~677	0.08~0 85	1 40~6.70	0.40~2.00	0 15~1 25

† No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively.

Table 3. Comparison of growth characteristics and yield of 4-year-old ginseng by upland and paddy cultivation.

Treat.	Region	Rate of survival plant (%)	Stem length (cm)	Stem diameter (mm)	LAI	T/R ratio (%)	Fresh root wt. (kg/3.3 m ²)
Upland	A1 ¹⁾	63.9	36.1	7.2	1.98	81.9	1.17
	A2	63.0	41.5	6.6	1.10	65.9	1.91
	U3	81.8	41.6	6.0	1.55	66.1	0.95
	U4	90.5	50.8	7.5	1.33	58.2	2.33
	P5	96.4	35.3	6.8	1.42	67.9	2.16
	P6	75.8	46.7	7.4	1.05	61.2	2.59
	K7	33.2	41.5	6.8	1.38	70.8	1.84
	K8	49.5	49.6	8.1	1.41	73.3	2.71
	Aver	69 3 ± 21.2	42.9 ± 5.8	7.1 ± 0 6	1.40 ± 0.29	68 2 ± 7 4	1 96 ± 0 63
	C. V	30.6	13.4	9.1	20.5	10.80	32.3
Paddy	U1	57.2	35.8	5.9	1.96	61.3	1.96
	U2	50.2	44.6	6.2	0.82	64.4	1.56
	P3	87.1	41.6	7.4	1.77	60.6	2.18
	P4	84.5	33.9	7.9	0.93	52.2	1.96
	K5	45.5	46.3	7.0	1.55	65.6	1.73
	K6	61.9	43.4	6.9	0.95	77.6	1.65
	K7	78.8	43.5	7.0	1.02	72.4	1.48
	Aver.	66.5 ± 16.9	41.3 ± 4.7	6.9 ± 0.7	1.29 ± 0.46	64 9 ± 8 3	1.79 ± 0.25
	C. V.	25.4	11.3	9.8	36.0	12 76	14.1
	LSD(5%)	12.50	5.74	1.11	0.21	7.95	0.53

† No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively.

1) Abbreviation A; Ansong, U: Umsung, P: Punggi, K: Kumsan

Experiment plot was arrayed by randomized block design with 3 replications and each plot size was 3.3 m². Soil physical properties were measured by monthly on April, June, August, and October, and soil chemical properties of the experimental plots analyzed in the late April were presented in Table 1 and 2. Top growth was investigated in the late June when it was grown completely. Underground growth was investigated in the middle of October, the optimal harvest time. Hardness of taproot was measured with TA-HD Texture Analyser(Korea, NHK Treading Co.) after harvest, and fresh root was separated into four parts of rhizome, taproot, lateral root, and fine root, and dried at 60 °C. Extract content was analyzed after extracting with 80 % ethanol by two times for 3 hours.

RESULTS AND DISCUSSION

Upland ginseng averagely showed higher rate of survival plant, length and diameter of stem, leaf area index, and top/root ratio than those of paddy ginseng as described in Table 3. Although yield's variation in upland ginseng was greater

than that of paddy ginseng, fresh root weight per 3.3 cm² was 1.96 kg (0.95 ~ 2.71 kg), and 1.79 kg (1.48 ~ 2.18 kg) in upland and paddy-soil field of 4-year-old ginseng, respectively. Ahn *et al.* (2002) reported that root weight significantly showed positive correlation coefficient with the growth of above-ground part. But Lee *et al.*(1995) reported opposingly that yield of paddy ginseng was averagely higher than that of upland ginseng in the northern part of Gyeonggi province known as main producing district of 6-year-old ginseng.

Length and diameter of taproot were not showed distinct difference between upland and paddy ginseng, and the ratio of diameter to length in taproot was also similar to each other as described in Table 4. Paddy ginseng showed large variation of 5.3 ~ 8.9 cm in length of taproot, while upland ginseng showed large variation of 16.3 ~ 28.3 cm in diameter of taproot. Moisture content of fresh root was 71.8% (68.5 ~ 73.1%) and 72.7% (70.2 ~ 74.9%) and the ratio of rusty colored root was 12.2% (0 ~ 44.7%) and 32.1% (7.37 ~ 7.5%) in upland and paddy ginseng, respectively. Hardness of taproot in paddy ginseng was higher than that of

Table 4. Comparison of characteristics of root growth in 4-year-old ginseng by upland and paddy cultivation.

Treat.	Region	Length of taproot (cm)	Diameter of taproot (mm)	Rate of D/L	Moisture content of root (%)	Hardness of root (g/3.14mm ²)	Rate of rusty colored root (%)
Upland	A1 ¹⁾	7.4	20.5	0.28	72.4	1,390	10.2
	A2	7.5	27.5	0.37	70.0	1,542	0.0
	U3	6.7	23.0	0.34	73.1	1,647	22.2
	U4	7.1	26.2	0.37	72.9	1,551	44.7
	P5	5.9	20.4	0.35	68.5	1,398	5.4
	P6	7.8	28.3	0.36	72.3	1,361	2.8
	K7	8.2	16.3	0.20	72.4	1,584	8.2
	K8	8.1	27.6	0.34	72.4	1,931	3.7
	Aver.	7.3 ± 0.8	23.7 ± 4.4	0.33 ± 0.07	71.8 ± 1.6	1,551 ± 185	12.2 ± 14.8
C. V	10.4	18.4	18.1	2.3	12.0	121.8	
Paddy	U1	8.0	21.0	0.26	73.1	1,597	35.0
	U2	5.8	27.6	0.48	74.9	1,648	52.3
	P3	7.4	23.2	0.31	70.2	1,750	25.5
	P4	6.0	25.5	0.43	73.2	1,733	16.1
	K5	8.9	21.1	0.24	73.2	1,713	7.3
	K6	6.1	25.0	0.41	71.0	1,911	10.7
	K7	5.3	24.1	0.45	73.2	1,762	77.5
	Aver.	6.8 ± 1.3	23.9 ± 2.4	0.37 ± 0.08	72.7 ± 1.6	1,731 ± 99	32.1 ± 25.3
	C. V	19.6	10.0	26.1	2.2	5.7	79.0
LSD(5%)	1.62	3.61	NS	1.09	192.2	24.2	

[†]Rate of D/L . Ratio of length to diameter in taproot

[‡]No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively.

1) Abbreviation A; Ansong, U; Umsung, P; Punggi, K; Kumsan

upland ginseng. Therefore, it was assumed that ginseng cultivated in paddy-soil showed denser structure than that of upland ginseng. Lee *et al.*(1995) reported that paddy ginseng showed more dense structure in taproot than that of upland ginseng, and the dense root might be more suitable as a material for red-ginseng.

Dry weight of upland ginseng was greater than that of paddy ginseng in all parts of rhizome, taproot, and lateral and fine root, but dry weight of other parts except fine root in upland ginseng showed larger variation than that of paddy

ginseng as described in Table 5. Taproot and rhizome of paddy ginseng especially showed small variation in comparison with upland ginseng. Both of upland and paddy ginseng showed greatest variation in lateral root weight among underground parts. Ratio of dry weight showed distinct difference between upland and paddy ginseng, but that of upland ginseng was especially small in taproot, and large in lateral root in comparison with paddy ginseng, and this result was similar to the report by Lee *et al.* (1995), and the reason why the growth of lateral root in paddy ginseng was

Table 5. Comparison of dry weight in root of 4-year-old ginseng by upland and paddy cultivation.

Treat.	Region	Dry matter weight (g/plant)				Ratio of dry weight (%)			
		Rhizome	Taproot	Lateral	Fine	Rhizome	Taproot	Lateral	Fine
Upland	A1 ¹⁾	0.40	6.80	3.23	1.12	3.5	60.8	26.4	9.4
	A2	0.94	12.65	4.37	1.73	4.8	64.8	22.0	8.5
	U3	0.24	3.02	1.24	0.90	4.1	55.9	22.8	17.2
	U4	0.52	9.86	5.29	1.62	3.0	57.1	30.5	9.4
	P5	0.50	10.89	3.76	1.82	2.9	64.5	21.9	10.7
	P6	0.57	12.98	4.02	1.76	2.6	58.0	31.7	7.8
	K7	0.35	7.62	1.35	0.83	3.5	75.0	13.3	8.2
	K8	0.69	11.95	4.08	1.79	3.0	59.0	27.9	10.1
	Aver.	0.53 ± 0.2	9.47 ± 3.4	3.79 ± 1.9	1.45 ± 0.4	3.4 ± 0.7	61.9 ± 6.2	24.6 ± 5.9	10.2 ± 3.0
	C.V.	41.2	36.3	50.7	29.2	21.2	10.1	24.1	29.6
Paddy	U1	0.46	9.26	1.84	1.13	3.7	72.4	14.8	9.0
	U2	0.43	8.12	3.75	1.08	3.2	60.9	27.8	8.1
	P3	0.52	8.23	4.78	1.99	3.4	53.0	30.8	12.8
	P4	0.33	8.91	1.79	0.86	2.7	75.1	15.0	7.2
	K5	0.37	9.47	1.38	0.95	3.0	77.7	11.6	7.7
	K6	0.49	9.56	4.58	1.65	3.7	65.3	21.2	9.7
	K7	0.38	6.84	2.57	1.39	3.4	61.2	23.0	12.5
	Aver.	0.43 ± 0.1	8.6 ± 1.0	2.96 ± 1.4	1.29 ± 0.4	3.3 ± 0.4	65.5 ± 8.9	20.6 ± 7.1	9.6 ± 2.3
	C.V.	16.2	11.3	47.5	31.6	10.9	13.4	34.8	23.6
	LSD(%)	0.21	3.09	1.78	0.71	0.44	NS	8.50	1.94

[†]No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively

1) Abbreviation A, Ansong, U: Umsung, P: Punggi, K: Kumsan

Table 6. distribution of root weight in 4-year-old ginseng by upland and paddy cultivation

(%)

Treat		100 g more	80 ~ 99 g	60 ~ 79 g	40 ~ 59 g	20 ~ 39 g	20 g less	Rate of above 60 g
Upland	Aver	1.2 ± 1.3	3.3 ± 3.4	9.2 ± 6.6	17.8 ± 8.9	34.4 ± 9.9	34.2 ± 15.2	13.7 ± 10.7
	Range	0.0 ~ 3.5	0.0 ~ 9.5	0.8 ~ 16.0	3.3 ~ 29.0	26.3 ~ 55.0	18.8 ~ 59.6	1.3 ~ 28.0
	C.V.	113.0	102.6	70.9	49.9	28.7	44.5	78.2
Paddy	Aver	0.2 ± 0.4	2.0 ± 1.6	5.6 ± 2.2	21.1 ± 6.4	36.7 ± 8.0	34.4 ± 8.8	7.8 ± 6.4
	Range	0.0 ~ 0.9	0. ~ 04.8	1.6 ~ 6.9	9.9 ~ 29.5	25.5 ~ 49.0	24.0 ~ 50.6	1.61 ~ 2.6
	C.V.	180.3	80.3	39.8	30.1	21.8	25.6	45.6

[†]No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively.

Table 7. Comparison of 80% ethanol extract content in 4-year-old ginseng between upland and paddy cultivation.

Treat.	Region	80 % ethanol extracts (%)	
		Taproot	Lateral root
Upland	A1 ¹⁾	19.6	24.4
	A2	20.3	22.1
	U3	20.3	32.5
	U4	17.3	24.3
	P5	20.2	28.8
	P6	19.3	32.1
	K7	19.1	24.3
	K8	22.0	30.3
	Aver	19.8 ± 1.3	27.3 ± 4.0
	C. V.	6.7	14.7
Paddy	U1	17.9	25.7
	U2	25.1	32.1
	P3	20.9	26.9
	P4	19.0	24.4
	K5	16.1	26.1
	K6	18.6	25.7
	K7	22.8	32.1
	Aver	20.1 ± 3.1	27.5 ± 3.2
	C. V.	15.4	11.6
	LSD(%)		1.13

[†]No. of investigated field was 8 and 7 in upland and paddy ginseng, respectively.

1) Abbreviation A; Ansung, U: Umsung, P: Punggi, K: Kumsan

relatively poor could be inferred from higher soil moisture content than that of upland-soil as showed in Table 1. There were especially large variations in lateral and fine root according to individual ginseng farm like 11.6 ~ 30.8% in lateral root, and 7.21 ~ 7.2% in fine root.

Percentage of above 60 g root to total harvested roots was 13.7% (0.8 ~ 28.0%) and 7.7% (1.6 ~ 12.6%) in upland and paddy ginseng, respectively. Percentage of big root showing 100 g or more in 4-year-old ginseng was also small such as 1.2% (0.0 ~ 3.5%), 0.2 % (0.0 ~ 0.9%), in upland and paddy ginseng, respectively (Table 6).

Extract content of taproot and lateral root didn't show distinct difference between upland and paddy ginseng as described in Table 7. Though Jo *et al.* (1996) and Lee *et al.* (1995) reported that content of saponin and extract showed no distinct difference between upland and paddy ginseng, extract content of this experiment showed large variation

according to individual ginseng farm such as 16.1 ~ 25.1 % in taproot, and 22.1 ~ 32.5 % in lateral root. Its variation in taproot of paddy ginseng was greater than that of upland ginseng, while lateral root of paddy ginseng showed smaller variation than that of upland ginseng.

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