

Changes in Growth, Yield and Active Content of *Atractylodes macrocephala* seedling in different growth stage

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Background

‘*Atractylodes* rhizome white(白朮)’ is a dried rhizomes of *Atractylodes macrocephala* K.(Fig. 1) or *A. japonica* K. and has long been used for gastric treatment, so it is widely used in traditional medicines along with ginseng and licorice. As a representative import-dependent medicinal crop, about 1,462 tons(\$ 2.7 million), or 92% of the total distribution, are imported(’19). In addition, as the functional food market has grown recently, the scale of domestic cultivation production is expanding. Therefore, the growth characteristics and active content of *A.macrocephala*, a species that is mainly cultivated and easy to reproduce seeds, were investigated.



Fig. 1. *Atractylodes macrocephla* K.

Materials and Methods

In mid-February, *A. macrocephala* seeds were planted in greenhouses, and in mid-April, seedlings were transplanted to investigate their growth characteristics and active contents every month in the experimental field at the department of Herbal Crop Research located in Eumseong. The distance between two adjacent plants was 30×15 cm maintained and applied 7-4-3 Kg of fertilizer (N-P₂O-K₂O)/10a. The number of the surveyed population is 20 individuals per one cultivar. The field experiment was conducted at the department of Herbal Crop Research located in Eumseong-gun, Chungcheongbuk-do. We investigated growth characteristics including rhizome length,, rhizome diameter, rhizome weight, yield.

In addition, Atractylenolides I and atractylenolides III were analyzed using HPLC instrument (Agilent 1260 series, Agilent Technologies, USA). The analyzed column was YMC basic – Pack ODS-AM (250 * 4.6 mm ,5 μm), and the column temperature was maintained at 35°C. The injection volume of the sample was 10 ul, the UV-wavelength was analyzed at 255 nm, the flow rate was eluted at 1 ml per minute, and the conditions of the mobile phase are presented in Table 1.

Table 1. Mobile phase condition of chromatographic separation.

Time (min)	Flow (mℓ/min)	Mobile phase (%)	
		0.1% Formic acid/Water	Acetonitrile
0	1.0	90	10
30	1.0	10	90
35	1.0	0	100
45	1.0	90	10
60	1.0	90	10

Table 2. Calibraion curve equations of atractylenolide I, atractylenolide II, and atractylenolide III.

Sample	Equation*	R ²
Atractylenolide I	y=18.43977x + 0.329546	0.99995
Atractylenolide III	y=1.16496x – 0.153867	0.99884

*y: peak area, x: concentration

Results and Conclusion

Between mid-June and mid-July, plant height, stem diameter and No. of leaves increased rapidly. The fresh and dry weight of aerial part steadily increased from mid-June to mid-October and then decreased(Table 3). The length of rhizome increased until mid-October, and then growth stopped, but the rhizome diameter steadily increased until mid-November. The growth of underground part such as dry weight of rhizome increased rapidly from mid-June to mid-July, and then steadily increased until mid-November(Table 4). Atractylenolide I and Atractylenolide III were the highest in mid-August and mid-November(Table 5). Each of these periods is before the flower buds have grown extremely large or the aerial part of plants have completely dried out.

In summary, growth of aerial part peaked around mid-October, but growth of underground part growth steadily increased until mid-November. The active contents were highest in mid-August and mid-November. These results can help researchers and farmers by providing basic physiological information about *A.macrocephala*.

Table 3. Changes in Growth of aerial part of *A. macrocephala* seedling in different growth stage.

Growth stage (Harvest time)	Plant height (cm)	Stem diameter (mm)	No. of stem	No. of branch	Leaf length (㎝)	Leaf width (㎝)	No. of leaves	Fresh weight of aerial part (g)	Dry weight of aerial part (g)	relative growth rate
mid-May	10.3 ^c	3.9 ^c	-	-	5.7 ^b	3.6 ^a	4.6 ^c	1.2 ^d	0.2 ^d	-
mid-June	16.2 ^b	4.9 ^b	-	-	7.7 ^a	3.1 ^b	9.6 ^c	6.4 ^d	0.6 ^d	3.69
mid-July	30.2 ^a	6.8 ^a	1.5 ^a	6.9 ^a	8.3 ^a	3.2 ^{ab}	39.8 ^a	516.0 ^c	136.7 ^c	211.03
mid-August	30.4 ^a	7.0 ^a	1.7 ^a	6.1 ^a	7.8 ^a	3.1 ^b	45.8 ^a	572.2 ^c	165.7 ^c	1.08
mid-September	32.1 ^a	6.0 ^a	1.9 ^a	6.7 ^a	7.3 ^a	3.0 ^b	47.1 ^a	944.8 ^b	276.2 ^b	1.62
mid-October	32.4 ^a	6.4 ^a	2.1 ^a	6.3 ^a	7.5 ^a	3.1 ^b	23.1 ^b	1299.0 ^a	377.8 ^a	1.34
mid-November	-	-	-	-	-	-	-	1007.8 ^b	347.7 ^{ab}	0.81

*Means within a column followed by the same letter are not significant based on the DMRT (p < 0.05).



Fig. 2. Growth of *A. macrocephala* in different growth stage (A: June , B: July , C: August, D: September, E: October, F: November)

Table 4. Changes in growth characteristics of underground part of *A. macrocephala* seedling in different growth stage.

Growth stage (Harvest time)	Rhizome : length (mm)	Rhizome : diameter (mm)	Rhizome : fresh weight (g)	Rhizome : dry weight (g)	relative growth rate
mid-May	1.4±0.3 ^d	5.4±0.9 ^f	0.3±0.0 ^d	0.1±0.0 ^e	-
mid-June	2.1±0.5 ^c	10.1±2.1 ^e	3.3±0.4 ^d	0.2±0.0 ^e	3.69
mid-July	2.9±0.8 ^b	18.5±3.6 ^d	74.3±7.5 ^c	16.3±0.8 ^{de}	74.66
mid-August	3.1±0.7 ^b	22.2±4.4 ^c	112±18.1 ^{bc}	33.0±2.5 ^{cd}	1.94
mid-September	3.3±1.1 ^b	25±5.1 ^b	156.8±10.9 ^b	44.3±4.1 ^{bc}	1.42
mid-October	3.9±0.7 ^a	27.7±9.4 ^b	260.5±53.0 ^a	67±17.2 ^b	1.47
mid-November	4.0±1.3 ^a	31.6±7.6 ^a	298.3±81.3 ^a	98±32.8 ^a	1.13

*Means within a column followed by the same letter are not significant based on the DMRT (p < 0.05).

Table 5. Changes in active contents of underground part of *A. macrocephala* seedling in different growth stage.

Growth stage (Harvest time)	AtractylenolideI (mg/g)	AtractylenolideIII (mg/g)	Total active content (mg/g)	Total active content per individual (mg/g)
mid-May	0.1892±0.0356	0.3117±0.0403	0.5009	0.03
mid-June	0.1410±0.0156	0.1612±0.0465	0.3022	0.07
mid-July	0.2452±0.0420	0.1981±0.0244	0.4434	7.24
mid-August	0.2832±0.0871	0.4821±0.2022	0.7653	25.25
mid-September	0.2711±0.0347	0.2284±0.0274	0.4995	22.14
mid-October	0.2431±0.1452	0.2648±0.1138	0.5079	18.79
mid-November	0.2767±0.0755	0.4886±0.1187	0.7653	75.00