

## Root Yields and Saikosaponin Contents Depending on Planting Time and Cultivated Regions of *Bupleurum falcatum* L.

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**ABSTRACT :** In order to decide the optimum planting time for *Bupleurum falcatum* L. which is grown widely in Korea, some experiments were carried out in different regions such as mid-north area (Gangwon-do, Gyeonggi-do and Chungcheongnam-do), mid-south area (Jeollanam-do, Jeollabuk-do, Gyeongsangnam-do and Gyeongsangbuk-do). The mid-south area had the highest total saikosaponin contents of 1.001, which is the medicinal ingredients of *Bupleurum falcatum* L., in accordance with the different *Bupleurum falcatum* L. regions. Also this area has the highest extract contents of 24.3%. Average dry root yields in mid-north area (Gangwon-do) were 450~460 kg/ha at planting time of March 20th to March 30th, 500 kg/ha at the time of March 30th to April 10th, and 470~480 kg/ha at the time of March 10th to March 20th in Chungcheongnam-do. The optimum planting time in the mid-south area (Jeollabuk-do) was March 10th to March 30th with the average dry root yield of 490~550 kg/ha. Average dry root yield in Euseong, Gyeongsangbuk-do area was 470 kg/ha, and the optimum planting time was April 10th, which suggested that the yield increased as the planting time was delayed. At Jeju-do, the volcanic soil of far-southern area, average dry root yield was 510 kg/ha at the time of March 10th, but the yield from non-volcanic soil was lower than from volcanic soil, which had a dry root yield of 470 kg/ha.

**Key word :** *Bupleurum falcatum* L. Planting time, Growth root yield, Dry root yield, Saikosaponin contents

### INTRODUCTION

*Bupleurum falcatum* L., is a perennial plant, which belongs to Umbelliferae in a systematic botany. The height of the plant is about 40~70 cm, and it is used for medicinal purposes (Jung, 1993 & Kim, 1995). Main producing regions of *Bupleurum falcatum* L. are Korea, China, and Japan (Akemi, 1989) however, it is widely cultivated from Asia to Europe, and it is classified to a subspecies and a variety in accordance with its shape and size of its leaves and fruits (Hideaki *et al.*, 1997). It was reported that there are about 150 species of (Kim, 1995 and Mun, 1991) only at the northern hemisphere. In Korea, it was reported to grow *Bupleurum falcatum* L., *B. scorzoniferolium* WILLD. *B. euphratioides* NAKAI, *B. longiradiatum* TUREZ, *B. latissimum* NAKAI, and *B. longeradiatum* (Kim, 1995, Turczaninow) which also has nicknames like MOETMINARI, CHAMNAMUL etc (Jung, 1993). A root of *Bupleurum falcatum* L. is a well-known and well-used herbal remedy for bringing down the fever (Mun, 1991), alleviation/sedation of pain, anti-inflammation, getting rid of one's cough, and improving the

function of a liver, a bilious and metabolism of Anti-dyslipidemics, since it shows a good efficacy as a remedy. The chief element of *Bupleurum falcatum* L. is saikosaponin A (Akira and Kiyomi *et al.* 1974), and *Bupleurum falcatum* L. is cultivated much as a single species in any medicinal plants. Therefore, in 1997, the yield per cultivation region was 264 M/T per 143 ha, and the average weight of fresh and dry root produced was 460 kg/ha. Also, it is mainly exported to Japan, since *Bupleurum falcatum* L. is one of the most export-promising medicinal plants out of all. But, a cultivation of *Bupleurum falcatum* L. has low sprouting percentage and low seedling stand rate (Hideaki *et al.* 1977), since the time required to sprout is long, which becomes an issue. Also it is widely cultivated from far-southern area (Jeju-do) to in mid-north area (Gangwon-do), yet these regions have very different sowing seasons. Therefore, this experiment is performed to investigate the differences in the medicinal value of ingredient contents for different sowing seasons and appropriate planting time in different regions with its root yields.

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## MATERIALS AND METHODS

This experiment was performed by dividing the *Bupleurum falcatum* L. cultivation regions into 3 regional groups, using the three-province of *Bupleurum falcatum* L. species as a publicly notified ingredient for three years from 1993 to 1995. The three regional groups are a mid-north area (Gyeonggi-do Suwon, Gangwon-do Chuncheon & Pyeongchang, Chungcheongnam-do Daejeon), mid-south area (Jeollabuk-do Iksan, Jeollanam-do Naju, Gyeongsangbuk-do Euseong, Gyeongsangnam-do Hamyang), and far-southern area (Jeju-do Jeju-city). For the whole amount of a standard fertilizer, 20,000 kg/ha of compost and 130-120-120 kg/ha of phosphoric acid (N-P<sub>2</sub>O<sub>5</sub>-K<sub>2</sub>O) were used. The 40% of N and K<sub>2</sub>O from phosphoric acid was used for the basal fertilization and the rest of the fertilizer was used as a supplementary for the months of June and August by a split application. As for the planting time, *Bupleurum falcatum* L. was sowed 4 times from February 20th to March 30th at ten-day intervals in Jeju-do of far-southern area. In the mid-south area, *Bupleurum falcatum* L. was seeded 6 times from March 10th to April 30th at ten-day intervals, and again *Bupleurum falcatum* L. was planted 5 times from March 20th to April 30th at ten-day intervals in mid-north area. A sowing method used for this experiment was drill seeding, which *Bupleurum falcatum* L., was planted in lines of three with 30 cm-interval in the ditch with the ridge width of 90 cm. The randomized block design was used for the arrangement of testing regions, and this experiment was replicated for three times to get precise and accurate results. The straw covering was used as the testing linen screen to improve the sprouting percentage in all regions. Main rearing characteristics investigated were emergence rate (seedling stand rate), plant heights, stem diameter, root lengths, root diameters, and weights of both fresh and dry roots. Also, the investigating standard was applied correspondingly to the inquiry of medicinal plants of an Youngnam Agricultural Research Institute by Rural Development Administration (RDA). To extract the saikosaponin of *Bupleurum falcatum* L. which was taken from average of different regions some roots of *Bupleurum falcatum* L. were dried with hot air of 65 °C, and then were ground up for three minutes to make *Bupleurum falcatum* L. a very fine powder. Methanol was added twice in three days to the 2 g of the ground *Bupleurum falcatum* L. powder with warming of two hours. The total 200 ml of an extract and non-extractable solutions were used for the quantitative analysis of saikosaponin. The 150 ml solution was analyzed by HPLC analysis, and the rest (50 ml) of solutions were analyzed by concentrating the solution in a vacuum to estimate the quantity of saikosaponin. At this time, HPLC used was the Thermo Separation

**Table 1.** Analytical conditions for saikosaponin in *Bupleurum falcatum* L.

Column : NoVa-pak C18
Mobil phase ; 65 : 35 (saikosaponin a), 60 : 40 (saikosaponin d)
Detection : UV 203nm
Flow rate : 0.9 ml/min
Injection volume : 10 µl

**Table 2.** Percentage of saikosaponin and extract according to different regions in *Bupleurum falcatum* L.

Region	Saikosaponin contents				Extract (%)
	a	c	d	Total	
Mid-north	0.313 <sup>c</sup> <sup>J</sup>	0.170 <sup>a</sup>	0.355 <sup>c</sup>	0.838 <sup>c</sup>	23.6 <sup>a</sup>
Mid-south	0.394 <sup>a</sup>	0.163 <sup>b</sup>	0.420 <sup>a</sup>	1.001 <sup>a</sup>	24.3 <sup>a</sup>
Far-south	0.354 <sup>b</sup>	0.152 <sup>c</sup>	0.405 <sup>b</sup>	0.911 <sup>b</sup>	23.3 <sup>a</sup>

<sup>J</sup> Means with the same letters in a column are not significantly different at the 5% level by DMRT.

<sup>b</sup> This is the average of each different region.

Products Co. P2,000 and conditions for HPLC analysis were same as shown in Table 1.

## RESULTS AND DISCUSSION

Generally, *Bupleurum falcatum* L. contains relatively higher level of saikosaponin D than others such as saikosaponin A, C in plant. Most of saikosaponin components usually accumulated in root, stem and leaf. Especially, much content of saikosaponin D with strong medical activity also accumulated in leaf. Park *et al.* (1994) reported that total saikosaponin content in 2 year root was about 0.40~1.31% which is lower than that of 1 year root, and native variety collected from Euseong contained relatively higher saikosaponin contents than others from Daejeon and Chuncheon.

The mid-south area had the highest total saikosaponin contents of 1.001, which is the medicinal ingredients of *Bupleurum falcatum* L., in accordance with the different *Bupleurum falcatum* L. regions. Also this area has the highest extract contents of 24.3%, as shown in Table 2.

*Bupleurum falcatum* L., is one of traditional medicinal crops and much sensitive to the environmental conditions. Especially, saikosaponin compound levels were showed to decrease at the mid-north region, which was corresponded to the report that amount of saikosaponin compound was decreased under conditions of low temperature, high humidity and high soil water content.

As for the plant height, the mid-north mountains area had

**Table 3.** Plant height and stem diameter according to planting time and different regions in *Bupleurum falcatum* L.

Planting time	Plant height (cm)		Stem diameter (mm)	
	Mid-north area	Mid-south area	Mid-north area	Mid-south area
March 10th	-	59.2 <sup>a</sup> ↓	-	4.5 <sup>ab</sup>
March 20th	67.7 <sup>a</sup>	58.2 <sup>b</sup>	4.2 <sup>b</sup>	4.6 <sup>a</sup>
March 30th	67.3 <sup>a</sup>	55.6 <sup>bc</sup>	4.6 <sup>a</sup>	4.2 <sup>b</sup>
April 10th	63.4 <sup>ab</sup>	47.7 <sup>c</sup>	4.4 <sup>ab</sup>	3.9 <sup>c</sup>
April 20th	60.8 <sup>b</sup>	58.2 <sup>b</sup>	4.2 <sup>b</sup>	4.4 <sup>b</sup>
April 30th	56.9 <sup>bc</sup>	42.0 <sup>d</sup>	4.4 <sup>ab</sup>	3.3 <sup>d</sup>

↓ Means with the same letters in a column are not significantly different at the 5% level by DMRT.

**Table 4.** Root length and root diameter according to planting time and different regions in *Bupleurum falcatum* L.

Planting time	Root length (cm)		Root diameter (mm)	
	Mid-north area	Mid-south area	Mid-north area	Mid-south area
March 10th	-	11.7 <sup>b</sup> ↓	-	5.1 <sup>bc</sup>
March 20th	12.9 <sup>ab</sup>	11.2 <sup>c</sup>	6.2	4.8 <sup>bc</sup>
March 30th	13.6 <sup>a</sup>	11.2 <sup>ab</sup>	6.4 <sup>a</sup>	4.6 <sup>c</sup>
April 10th	13.6 <sup>a</sup>	11.6 <sup>b</sup>	5.7 <sup>ab</sup>	5.0 <sup>bc</sup>
April 20th	13.4 <sup>a</sup>	11.2 <sup>c</sup>	5.6 <sup>ab</sup>	4.7 <sup>c</sup>
April 30th	13.5 <sup>a</sup>	11.0 <sup>c</sup>	5.6 <sup>ab</sup>	4.3 <sup>c</sup>

↓ Means with the same letters in a column are not significantly different at the 5% level by DMRT

**Table 5.** Weights of both fresh and dry roots according to planting time and different regions in *Bupleurum falcatum* L.

Planting time	Fresh weight (gr)		Dry root weight (gr)	
	Mid-north area	Mid-south area	Mid-north area	Mid-south area
March 10th	-	117.8 <sup>b</sup> ↓	-	58.6 <sup>a</sup>
March 20th	143.1 <sup>a</sup>	105.1 <sup>c</sup>	45.9 <sup>b</sup>	55.3 <sup>a</sup>
March 30th	143.1 <sup>a</sup>	95.6 <sup>bc</sup>	44.6 <sup>b</sup>	48.4 <sup>b</sup>
April 10th	118.4 <sup>b</sup>	92.7 <sup>bc</sup>	43.5 <sup>b</sup>	42.8 <sup>b</sup>
April 20th	118.4 <sup>b</sup>	86.8 <sup>d</sup>	42.9 <sup>b</sup>	37.4 <sup>c</sup>
April 30th	113.0 <sup>b</sup>	83.2 <sup>d</sup>	36.9 <sup>c</sup>	33.3 <sup>c</sup>

↓ Means with the same letters in a column are not significantly different at the 5% level by DMRT

the tallest of 67.7 cm for the planting time of March 20th, and mid-south area had the tallest of 59.2 cm for the planting time of March 10th. As for the stem diameter, The mid-north mountains area has the thickest diameter of 4.6 mm at the planting time of March 30th, and the mid-south area also had the thickest of 4.6 mm at the planting time of March 20th. It was reported that optimum sowing date of *Bupleurum falcatum* L. was from early March to early April. In this study, it showed

that optimum showing date of *Bupleurum falcatum* L. in mid-north or mid-south region was middle or late March in view of the result that general growth rate of *Bupleurum falcatum* L. was gradually decreased at the sowing date of April.

As shown in Table 4, as for the root length and the diameter, mid-north area showed that the planting time of March 30th has the longest root length of 13.6 cm and the thickest root diameter of 6.4 mm. Also, the mid-south area indicated that the

planting time of March 10th had the longest root length of 11.7 cm and the thickest root diameter of 5.1 mm. Table 3 showed that total root yield of *Bupleurum falcatum* L. was relatively increased at the sowing date of early or middle March in the mid-south region and late March in the mid-north region. Table 5 also showed that average 117.8 g of fresh root as well as thicker stem diameter of plant was gathered at the sowing date of March 10th in the mid, south region, but sowing date of March 20th was showed relatively higher growth rate in mid-north region. Therefore, optimum sowing date of *Bupleurum falcatum* L. was estimated to the early or middle March.

In mid-north mountainous area, the yield of sowing regions and planting time were the highest from March 20th to March 30th for the yield of 475~497 kg/ha. Also, mid area that includes Suwon city as a center, showed the highest yield and planting time of 446~459 kg/ha during March 10th to March 20th. Generally, the yield was high in southern area, since the planting time was earlier than others, which is from March 10th to March 20th. Also, the yield in mid-north area was high of 475~497 kg/ha, even though planting time was about 10 days later (March 20th to March 30th) than in southern area. Traditional main production areas *Bupleurum falcatum* L. were Gangwon province Jeongsun, Chuncheon, Whacheon and Gyeonggi province (Echeon) In recent, the main areas have been changed to the Gyeongbuk province (Euseong, Yeongcheon) and Jeju province because yield and quality of *Bupleurum falcatum* L. in warm region was relatively better than those of cold region.

According to the tested soil of both volcanic and non-volcanic in the far-southern area are of Jeju-do, the results from the volcanic soil were generally better than the results from the non-volcanic soil, especially those of plant height, stem diameter, root length and its diameter, and weights of fresh and dry root, during the planting time from February 20th to March

20th. The results of different planting times showed that both volcanic and non-volcanic soil had the highest dry root yield of 510 and 470 kg/ha, respectively, at the time of March 10th. The only thing was that the number of days required for seedling emergence of non-volcanic soil was about 2 days faster than it is of volcanic soil. As the result of public testing by the three-province of *Bupleurum falcatum* L., seedling rate was the highest of 90% at Gangwon-do Chuncheon. The largest root length and its diameter were 19.7 cm and 7.4 mm, respectively at Chungcheongnam-do in mid-north area. The rate of seedling in mid-south area were high in Jeollanam-do and Jeollabuk-do, each 95% and 89%, respectively. The plant heights were high in Gyeongsangbuk-do and Jeollanam-do, 59.5 cm and 59.1 cm, respectively. Both root length and its diameter in Jeollabuk-do showed the highest of 13.3 cm and 5.2 mm. Jeju-do, in southern area, had most number of root 7.2/plant, and yields of root length were high in Gyeongsangbuk-do of 659 kg/ha and in Gyeongsangnam-do of 570 kg/ha. Average yield was 540 kg/ha and the three-province of *Bupleurum falcatum* L. indicated that the mid-south area was more suitable and appropriate for the *Bupleurum falcatum* L. cultivation than mid-north area. Optimum cultivation area of



Fig. 1. The sight of growing of *Bupleurum falcatum* L. at Milyang area in Gyeongsangnam-do.

Table 6. Effects of planting time of regions for plant growth of *Bupleurum falcatum* L. in Jeju-do of Korea.

Tested soil	Planting time (Month/day)	Plant height (cm)	Stem diameter (mm)	Root length (cm)	Root diameter (mm)	Fresh root (kg/ha)	Dry root (kg/ha)
Volcanic soil	Feb. 20th	60	5.9	11.9	6.6	990 <sup>dj</sup>	450 <sup>bc</sup>
	March 10th	60	5.6	11.6	6.1	1,140 <sup>b</sup>	510 <sup>a</sup>
	March 20th	60	5.0	11.5	6.0	1,050 <sup>c</sup>	470 <sup>b</sup>
	March 30th	58	5.1	11.7	6.0	1,070 <sup>c</sup>	470 <sup>b</sup>
Non-volcanic soil	Feb. 20th	52	4.6	9.7	5.7	1,040 <sup>c</sup>	420 <sup>c</sup>
	March 10th	48	4.8	9.1	5.3	1,200 <sup>a</sup>	470 <sup>b</sup>
	March 20th	51	4.1	8.8	4.9	1,160 <sup>b</sup>	450 <sup>bc</sup>
	March 30th	47	4.5	8.1	5.0	1,100 <sup>b</sup>	420 <sup>c</sup>

<sup>j</sup> Means with the same letters in a column are not significantly different at the 5% level by DMRT

**Table 7.** Physico-chemical characteristics of trial soil in *Bupleurum falcatum* L.

Soils	Soil texture	Water content in -33kp <sub>2</sub> (g/g)	pH (1:5)	O.M (g/kg)	Av.P <sub>2</sub> O <sub>5</sub> (mg/kg)	Ex.cations (cmol/kg)			Base exchange capacity (CEC) degree of saturation (cmol/kg)	
						Ca	Mg	K		
Non-volcanic ash soil (Gangjeong Series)	Silt loam	35.2	6.8	25	166.5	14.43	1.19	0.67	44.4	16.0
Volcanic ash soil (Songdang Series)	Silt loam	74.2	5.5	194	28.9	5.62	108	0.43	4.5	39.4

*Bupleurum falcatum* L. which is originated from Japan. It was southern part rather than northern part which is similar results of this study. In the aspects of its quality and components, in Gangwon-do province has the highest saikosaponin percentage of 1.019. Also, in Jeollabuk-do in mid-south area had the percentage of 0.935. Finally, Jeju-do, in far-southern area, indicated the percentage of 0.811. The average of south area was 0.845, which was bit higher than the percentage in Jeju-do. Also, the average of mid-north area was 0.747, and the average of total saikosaponin was higher in south area are rather than mid-north area.

The experimented soil has the distinctive physico-chemical properties, and the type of soil texture is silt loam. The volcanic soil has the water content of 74.2, which is twice as much as the non-volcanic soil, and also has higher contents of organic matters. The chemical trait of volcanic soil has high CEC, but its physical trait is average that makes soil to lose the nutrients easily, which usually indicates the lower base exchange capacity in the volcanic soil rather than it is of non-volcanic soil. According to its soil texture characteristics, volcanic soil is more appropriate for the cultivation of root vegetable and fruits. However, non-volcanic soil can supply proper nutrients so that the yield can be higher than volcanic soil for seed and crops.

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