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The Time for Collecting of *Cryptomeria japonica* Seeds

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Abstract - The time of seed collection is regarded as one of major concerns to obtain sound seeds. The physical and germinal aspects of *Cryptomeria japonica* D. Don (Taxodiaceae) seeds were analyzed to determine the optimum harvesting time in Korea. Cones were picked every 10 days from the 30th of July to the 30th of October in both 2005 and 2006. Seeds were collected from picked cones. Seed size and weight were not significant in two consecutive years. The 1,000-seed weight was 3.3 g for cones picked at the 18th of August and 5.3 g for cones picked at the 30th of September. The size of seeds was increased as the time of collection from the 18th of August to the 30th of September: from 19.3 mm to 21.3 mm in length and from 15.8 mm to 18.5 mm in width. Average germination rates in 2005 was 18.3% and 19.6% in 2006. The highest germination rate was 34.3% from seeds collected at the 30th of September in 2005. In 2006, the highest germination rate was 31.7% for seeds collected at the same date as the 2005 seeds. After the end of September, germination rate was decreased in both years. The results implied that the best cone picking time for Korean *C. japonica* seeds is around the end of September.

Key words - Embryos, Germination rate, Seed orchard, Seed size, Seed weight

Introduction

Japanese Cedar (*Cryptomeria japonica* D. Don (Taxodiaceae)) has been cultivated in China, Japan, Taiwan, and Korea. As one of evergreen trees, it grows up to about 60 m tall with red-brown bark, needle and globular seed cones. Like Japan, it is one of the economically important timber species, especially in southern part of Korea (Min *et al*., 1996). The wood is scented, reddish-pink in colour, lightweight but strong, waterproof, and resistant to decay. It is favorable for buildings, bridges, ships, lamp posts, furniture, utensils, and paper manufacture (Christopher, 2009; Hyun and Chon, 1987; JNTO, 2006).

Sound seeds have to get high germination rate as well as high productivity. Production of good seeds is an essential role of seed orchard to fulfill reforestation program and to get productive woodland for short time (Son *et al*., 2008). Since 1976, around 1,900 kg of *C. japonica* seeds have been produced from 30 ha of clonal seed orchard in Jeju island which is located in southern part of Korea. Some warm-temperate tree species including *C. japonica* and *Chamaecyparis* obtusa (Cupressaceae) are growing here. The seed orchards of those trees are the basis for supply seeds requiring replantation in the southern part of Korea. In Korea, the standard germination rate of *C. japonica* is 28%. Factors influencing germination rate are various, however, the collecting time of cones is regarded as one of the major concerns to increase germination rates (Harrington, 1972). Generally, seeds with high germination percentage and short period for germination were obtained from cones which had been collected at the best cone picking time. Less optimal cone collecting time could affect not only lower germination rate but also fewer total amounts of seed production (Ying *et al*., 1985; Choi *et al*., 2007).

The main objective of the study was to determine the optimum harvesting time of *C. japonica* seeds in Korea after analyzing the physical aspects, climatic factors, and investigating germination rates.

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Materials and Methods

Seed collection

Cones and seeds of *C. japonica* were collected from the seed orchard in Jeju island located in southern part of Korea.

Jeju Island is a volcanic island lied in 126° 08' 43"~126° 58' 20" of east longitude, 33° 11' 27"~33° 33' 50" (excluding islets) of north latitude. 40-year-old *C. japonica* trees with average seed productivity were chosen for the study and 20 cones from each tree were picked. The cones were harvested every 10 days from the 30th of July to the 31st of October in 2005 and 2006.

Seed aspects measurement

Total 60 seeds were randomly collected from the cones harvested at each picking date. Seed length and width were measured with a vernier calipers (573-605, Mitutoyo, Japan). Using a micro balance (CT1200F, Ohaus, U.S.A.), 1,000-seed weight (fresh weight; FW) was also measured three times to reduce variation. The data was statistically analyzed using SPSS Version 12.

Embryo characters and germination rate

For observation of embryos, seed-coats were removed and cut by vertical direction. Through microscopic analysis, embryos were classified by types and shapes. Germination tests were conducted from the 26th of March to the 20th of April both in 2006 and 2007 with three replications. 100 seeds were placed in a glass petri-dish with wetted Whatman filter paper and were incubated in a germination chamber. Incubating condition was 8/16 hr (day/night) at 24℃. Radicle emergences from seeds were daily recorded.

Analyzing climate factors

In 2004, 2005, and 2006, all climate data were from Seogwipo meteorological office in Jeju island. The annual average temperature, precipitation, and sum temperature were 16℃ - 17℃, 1,300 mm - 2,000 mm, and 4,100℃ - 4,700℃, respectively (Table 1). Among the climate factors, data about the amount of sunshine, accumulated temperature (>5℃), and precipitation which could mainly affect on the seed production were analyzed.

Results and discussion

Physical characteristics of seeds

Most flowers were blooming at the 15th of April in 2005 and 2006. Difference in seed size between seeds produced in 2005 and 2006 was not significant. The globular cones around 2 cm in diameter with 20-40 scales were ripening (Fig. 1). During the test period, seed length was between 19.3 mm to 21.6 mm and seed width ranged from 15.8 mm to 18.5 mm (Table 2). The seed size collected at the 30th of July was slightly larger than the one at the 18th of August. The 1,000-seed weight was from 3.31 g to 5.37 g. The seeds picked at the 18th of August were slightly heavier than those picked at the 30th of July.

This result could indicate that the cones were picked so early that the seeds were not matured enough. As a result, germplasm in the seeds was not hardened enough and these

Table 1. The weather aspects of *C. japonica* seed orchard of three consecutive years (data serviced by Seogwipo meteorological office)

Year	2004	2005	2006
Temperature (℃)	17.8	16.2	17.1
Precipitation (mm)	2,018.0	1,390.6	1,757.6
Accumulated Temperature (>5℃)	4,727.4	4,172.2	4,467.6

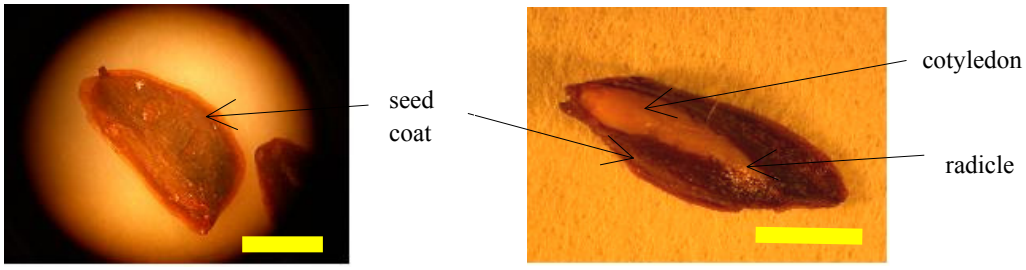
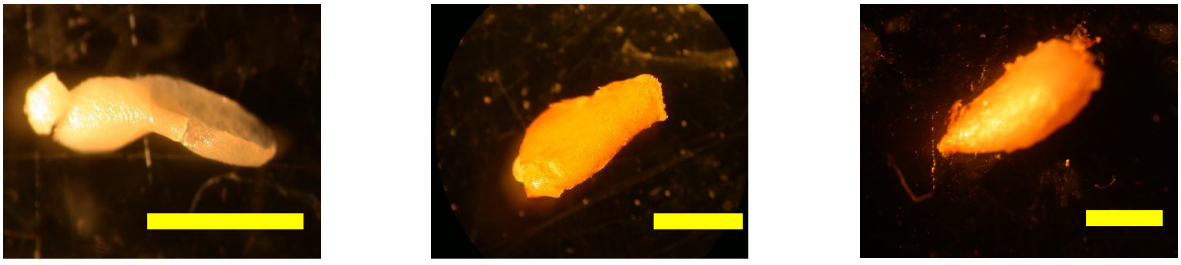


Fig. 1. Matured seed (left) and embryos opened by cut seed-coat (right) of *C. japonica* (bar equals 1 cm).

Table 2. The physical properties of *C. japonica* seeds. A different letters represent significant differences between times at $P \leq 0.05$

Cone picking date	Length (mm)	Width (mm)	Weight (FW, g)
30-Jul	19.9 [b]	17.2 [b]	3.6 [a]
18-Aug	19.3 [a]	15.8 [a]	3.3 [a]
30-Aug	20.6 [c]	17.9 [c]	4.0 [b]
10-Sep	20.7 [c]	18.4 [c]	4.0 [b]
20-Sep	21.6 [d]	18.5 [c]	5.0 [c]
30-Sep	21.3 [cd]	18.5 [c]	5.3 [d]
15-Oct	21.3 [cd]	18.5 [c]	5.4 [d]



2005.8.30 2005.9.15 2005.9.30

Fig. 2. Development of embryos depending on picking time of *C. japonica* seeds (bar equals 1 mm).

immature seeds seemed to be more flat-elliptic shape than the other seeds. Moisture contents which could represent the seed weight in the immature seeds were also higher than the mature ones (Krugman *et al*., 1974; Willan, 1987; Yoon *et al*., 1999).

Development of embryos

In each scale of the cones, 3-6 seeds were present. After revealing seed coat, several different types of embryos appeared depending on the picking time (Fig. 2).

Like seed size, differences in embryo characteristics between seeds produced in 2005 and 2006 was not significant. At the beginning, a germ-like shape of an embryo was taken from the seed picked at the 30th of July. Around one month later, the size of 2 mm long embryo was observed with somewhat hard shape. A full shaped embryo was seen from the seed picked at the 15th of September. It is important to know the periodic reconnaissance to check on the progress of fruit maturation. Son *et al*. (2008) reported that, depending on picking time, various shapes such as just liquid material, something jellied or the fully matured were observed in the seeds of *C. obtusa*. In their report, they concluded that observation of the

Fig. 3. Fully developed embryo from the seed of *C. japonica*. picked at 15th of October, 2005 (bar equals 1 mm).

fruit maturation progress could be helpful for increment of seed germination. Ng and Loh (1974) also emphasized the reconnaissance about the length of time between anthesis (flower opening/pollination) and fruit maturity to improve germination rates. Generally, in Korea, the seeds of *C. japonica* have been harvested in October. To get the higher germinability and to increase embryo weight, after-ripening is necessary. Yoo *et al*. (1996) reported that high germination (over 90%) of gourd seed could be obtained when fruits were harvested at least 70 days after anthesis or met an appropriate after-ripening period over 30 days. In this study, even though the perfect shape of embryo could be gotten at the picking time in

the middle October, the sound seeds would be obtained several days before with after-ripening. In this study, the hard and fully developed embryos were observed from the seeds picked at the 15th of October, with 15 days-after-ripening (Fig. 3).

Germination rates, cone harvest time, and climate factor

Radicles emerged about two weeks after placing in a glass petri-dish. The appearance of shoot was around 4 cm long with twirled shape and grey-white color (Fig. 4).

In test period, the average germination rates of 2005 and 2006 were 19.6% and 18.3%, respectively. Comparing the rates of two consecutive years, it was slightly superior in 2006 to 2005. Among many physiological and environmental conditions, climatic factors can affect the abundance of flowering and thus indirectly affect seed viability (Willan, 1987). Flowering and fruiting also require excess light and effective pollination (Carmenza, 2005). In particular, the meteorology from April to May could affect decisively on pollination and fertilization. Some papers reported that above-average temperatures and a modest degree of moisture stress in spring and early summer can induce abundant formation of flower buds in temperate regions (Krugman *et al*., 1974; Workneh and Rush, 2002). By comparison, the monthly amount of sunshine was greater in April, May and Jun of 2005. In case of *C. japonica*, the most anthesis occurred in the middle of April. After that the pollination and fertilization are processed during May and Jun. The amount of precipitation which could be an adverse effect on seed production was higher in 2006 than in 2005 (Fig. 5).

Meer *et al*. (2001) reported that a decrease in rainfall can also affect seed production caused by the development of flowering buds. According to data from Seogwipo meteorological office, the annual total precipitation was much greater in 2005 (7,159 mm) than in 2006 (3,764 mm). However, the monthly sum of precipitation in April, May and Jun were much less in 2005 (Fig. 6).

The amount of sound seeds depends on the number and size of the cones and the number of viable pinyons within the cones. Ultimately more seed production can produce more sound seeds consequently producing higher germinability (Parker *et al*. 2006). In the present study, the higher germination rate in 2005 could imply that more sound seeds were produced in 2005 than in 2006. The germination rate was observed as 13.3% from seeds picked at the 18th of August,

Fig. 4. Emerged radicle from the seed of *C. japonica*..

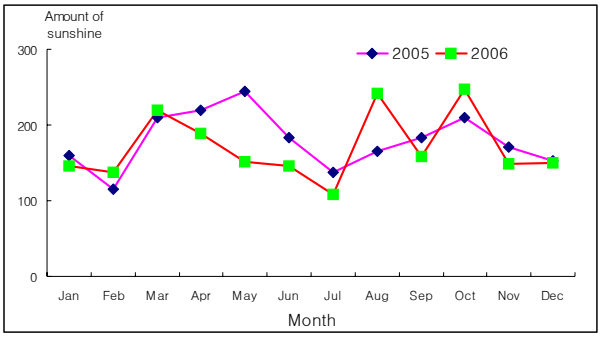


Fig. 5. Monthly sum of sunshine of two consecutive years.

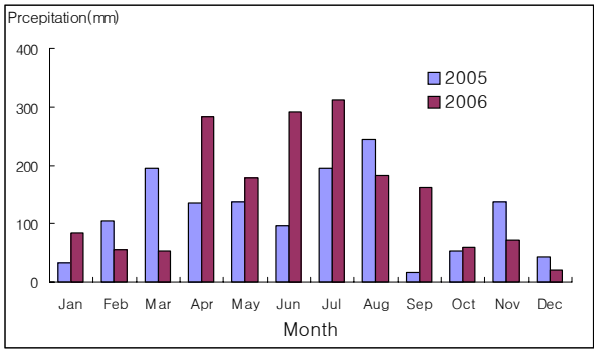


Fig. 6. Monthly sum of precipitation of two consecutive years.

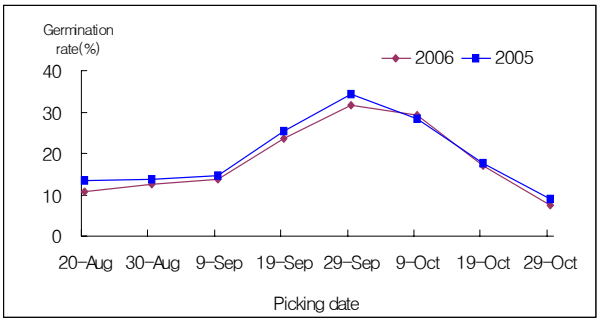


Fig. 7. Germination rate of *C. japonica* depending on picking time.

2005. In the seeds collected before this date, the germinal apparatuses were not shown. The highest germination rate was 34.3% from the seeds picked at the 30th of September, 2005 (Fig. 7).

In the seeds collected after early October, germination rate was decreased in the test trials picked at the 30th of October to 9.0% in 2005 and 7.3% in 2006. This result indicated that the matured and heavy seeds after early October could be dropped or dispersed by wind. The same tendency was shown in case of *C. obtusa* conducted by Son *et al*. (2008). Kim *et al*. (2003) also reported that post-maturity would be helpful for increment germination characteristics of *Kalopanax septemlobus* (Thunb. ex Murray) Koidz. seed. Therefore the ability of seeds can be affected by the adequate coned picking time. And the best picking time should be a date previous to full ripening of cones or of well-developed of embryos. In the Korean *C. japonica* seed orchard, the seeds have been generally harvested from the cones picked from the first ten days to the middle of October. In this study, the results recommend that the cones of *C. japonica* should be picked approximately at the last day of September.

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