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ORIGINAL ARTICLE

Verification on Cold-Tolerance of Some Fruit Trees as Species for Urban Greening Plants

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Abstract

This study selected commonly known species of fruit trees, and re-selected the species that endure the stress of extreme cold weather and physiologically restore themselves to the previous state until the following year. Then we could go ahead to propose the species that were appropriate as urban greening plants in weather condition of any part of the country. To do this, we conducted an experiments for six species of fruit trees based on the preference of the general public and recommendation of the experts; *Morus alba* (English name: mulberries), *Diospyros kaki* (English name: Persimmon), *Prunus persia* (English name: Peach), *Elaeagnus umbellata* var. *coreana* (English name: Korean Autumn Olive), *Malus domestica* 'Alps Otome' (English name: Alps Otome), and *Prunus mume* (English name: Blue Plum). The experiment verifies whether the trees survive without any stress from the cold weather under the national climate conditions (one in the suburbs of Seoul: Yongin city, one in the central Chungcheong region: Daejeon city, and in the southern Gyeongsang region: Jinju city in Korea). The experiment lasted for a year from August 2016 to August 2017. The levels of electrolytic efflux, chlorophyll content, plant height, fresh weight, and dry weight were measured four times (on August of 2016, January, February, and August of 2017) for each tree planted bare ground outdoors. Results showed that *Diospyros kaki*, *Prunus persia*, and *Malus domestica* 'Alps Otome' were proven durable and resistant to winters of all three areas (one in the suburbs of Seoul: Yongin city, one in the central Chungcheong region: Daejeon city, and in the southern Gyeongsang region: Jinju city in Korea). Especially, the increase of chlorophyll content and the reduction of electrolytic efflux were noticeable in *Prunus persia* than in the other two species, proving itself as the most cold-tolerant among the six species used in the experiment. In addition, interpreting from the physiological restoration data of one-year span before and after getting through winterer, *Prunus persia* was proven to be the most cold-tolerant species.

Key words : Fruit tree, Physiological restoration, Cold-torerant species, Chlorophyll content, Electrolytic efflux

1. Introduction

As an important greening policy of local governments to specialize their cities, fruit trees are often planted roadsides. However, fruit trees often freeze to death in winter in the suburbs of Seoul: Yongin city, depending on the species.

Recent climate changes have pushed up the northern growth limit of the fruit trees, indicating that with their cold-tolerance verified, the fruit trees that were planted in the southern region in Koera may be planted in the central Chungcheong region or in the

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suburbs of Seoul, enlarging to scope of utilization of fruit trees as urban greenning plant.

The important theory for the cold-tolerance of plants is that plants that conform to low temperature have lower transition temperature from outside to the cell membrane as the proportion of unsaturated fatty acids increases. This allows the function of cell to be protected without being damaged by maintaining the liquidity within the cell membrane (Willims et al., 1988).

In other words, the ability of a plant to endure the low temperature in the winter and restoration its physiological activity the following year indicates that the biorhythm to lower the plant's transition temperature functions efficiently.

Physiological resilience means that electrolytic substance in cell membrane is maintained without being demaged during the coldest days and the growth of plants is cotinued by active vegetative stage.

The biorhythm of a plant occurs in stages, called cold acclimation, and is caused by exposure to a single condition and a certain amount of low temperature (Kwon et al., 2001; Jeon, 2009).

The differences in genetically inherited susceptibility to cold stress (i.e. the cold-tolernace) were found to vary largely among the species, or among the entities within the same species (Hong et al., 1978), and such differences in the durability to the cold weather have been reported as an important measure in selection of cold-tolerant species.

There are many fruit trees cultivated in Korea, but cold-tolerant fruit trees that can endure the cold stress in the winters of the central Chungcheong region or the suburbs of Seoul have not yet been tested. Thus, this study selected the well-known fruit trees, and reselected those that physiologically restored themselves after the cold stress during the winter. This allowed us to suggest fruit tree species that could be planted anywhere in the country as urban greennig plants.

2. Scope and Methodology

2.1. Overview on cold-tolerance of fruits tree

2.1.1. Experiment overview

We selected six species of fruit trees based on the preference of the general public and recommendation of the experts who selected practicable fruit tree as greening plants (Lee and Nam, 2016); *Morus alba* (English name: mulberries), *Diospyros kaki* (English name: persimmon), *Prunus persia* (English name: peach), *Elaeagnus umbellata* var *coreana* (English name: Korean autumn olive), *Malus domestica* 'Alps Otome' (English name: Alps Otome), and *Prunus mume* (English name: blue plum). Then we experimented whether thees trees survive without any stress from the cold weather under the national climate conditions (one in the suburbs of Seoul: Yongin city, one in the central Chungcheong region: Daejeon city, and in the southern Gyeongsang region: Jinju city in Korea).

Since the physiological damage occurs to a certain degree within the plant while tolerating the low temperature stress during the winter, the degree of the phsiological recovery will depend on the degree of physiological damage. Therefore, in this study, we selected the fruit trees that have already endured the low temperature stress bare ground outdoors, and measure the restoration of physiological vitality and the degree of growth during the vigorous growth period from spring to summer the following year. After that, the species of fruit trees that can be planted nationwide is finally proposed as suitable urban greening species.

2.1.2. Scope and methodology

2.1.2.1. Regional scope and conditions of the tested

- Metropolitan region: A highschool in Yongin city
- Central region: A university in Daejeon city

Table 1. Changes in chlorophyll and electrolyte values of *Morus alba* during and after the winter season (by region)

Species	Region	Measurement item	2011.01	2017.02	2011.08	Note
Morus alba	Yongin	chlorophyll content(mg/g)	8.56±0.14a z)y)	13.89±4.36b		death during wintering
		electrolyte values(㎛/sec)	51.73±7.49a	51.13±0.82a		
	Daejeon	chlorophyll content(mg/g)	4.93±0.87a	7.31±1.02b	0±1.79	
		electrolyte values(㎛/sec)	48.59±2.34a	66.21±1.48b	0±0.82	
	Jinju	chlorophyll content(mg/g)	8.34±0.30a	9.62±1.36a		death during wintering
		electrolyte values(㎛/sec)	38.62±4.34c	16.41±1.05c		

z) standard error based on sample of treatment

y) Ducan test: mutiple testing, P<0.05

- Southern region: An area in Sacheon city of Gyeongsang Province

All testbeds were located on the bare ground outdoors, facing south to receive more than six hours of sunlight daily. Fruit trees were 2-3 years old, planted at least 30 cm below the ground level, as deeply as possible so that the root does not freeze. Transplanting accompanied sufficient provision of water considering the transplanting stress. The interspecific planting method was applied to 10 treatments per 1 fruit tree in the treatment plot.

2.1.2.2. Time scope

The experiment lasted for a year from August 2016 to August 2017. The levels of electrolytic efflux, chlorophyll content, plant height, fresh weight, and dry weight were measured four times (on August of 2016, January, February, and August of 2017) for each tree planted bare ground outdoors.

For investigating physiological recovery of six fruit trees, this experiments were proceeded in coldest momths (January and February, 2017) and most vitality period (August, 2016) as measuring physiological and growth item.

And through extreme situation during the coldest month (January and February, 2017), we proceeded this experiment to investigate how the ability of physiological and growth in 6 fruit trees of August, 2017 were recovered in comparison with that of I years ago.

3. Results and Implications

3.1. The survival ability of six species of evergreen Sedum after wintering

All *Morus alba* withered away during the winter season in Yongin city and Jinju city. Also in Daejeon city, most *Morus alba* withered in winter, providing no evidence of survival at any weather condition within the country. Moreover, although their level of chlorophyll content increased temporarily in Yongin city and Jinju city for a certain period of time, their later death makes it difficult to infer any regional significance (Table 1).

Although their level of electrolyte efflux was slightly decreased in Yongin and Daejeon during February 2017 in Jinju, it increased from 23.06 ㎍/g to 32.81 ㎍/g until decreasing to 3.63 ㎍/g in August 2017. Although it is most prominent proof of the phenomenon where electrolyte efflux decrease during the restoration and growth period, this does not explain regional deviations or significance. However, *Diospyros kaki* did not die after the winter season, which shows that the growth and recovery progressed well all over the country.

Nationwide, *Prunus mume* died after the winter season. In the Yongin and Daejeon area, the level of electrolytic efflux was higher than that of other fruit

Table 2. Changes in chlorophyll and electrolyte values of *Diospyros kaki* during and after the winter season (by region)

Species	Region	Measurement item	2017.01	2017.02	2017.08	Note
Diospyros kaki	Yongin	chlorophyll content(mg/g)	22.08±0.40a[z)y)]	23.16±0.75a	31.39±5.41a	
		electrolyte values(㎛/sec)	28.86±6.83b	31.61±0.96a	15.76±0.76b	
	Daejeon	chlorophyll content(mg/g)	10.45±0.17a	21.49±0.72a	35.73±3.75b	
		electrolyte values(㎛/sec)	34.74±5.67b	34.32±5.01c	17.56±9.47b	
	Jinju	chlorophyll content(mg/g)	10.50±0.50a	23.02±2.02c	31.5±4.19c	
		electrolyte values(㎛/sec)	24.06±1.22a	32.71±3.01b	3.53±0.24b	

z) standard error based on sample of treatment

y) Ducan test: mutiple testing, P<0.05

species during the same period of January and February 2017, indicating that the low temperature damage already started to take place (Table 3).

Elaeagnus umbellata var.*coreana* during the winter season showed a slightly decreased level of electrolytic efflux in Yongin and Deajeon, from 66.83 ㎍/g to 56.22 ㎍/g, and from 42.86 ㎍/g to to 36.18 ㎍/g respectively. However, they withered in Yongin city after the measurement. The level of chlorophyll contents varied according to the species and regions, and the nationwide cold-tolerance was not verified, so the fruit species suitable for the domestic climate were not selected (Table 4).

Malus domestica 'Alps Otome' showed an increase in the chlorophyll content level from Yongin, Daejeon, and Jinju areas during the winter and afterwards until the growth period. Also, the amount of electrolyte efflux decreased, indicating the most stable measurement value among the six fruit species used in this study (Table 5). In particular, it was found that the electrolyte efflux values are lower in the winter season and the growth period than the other fruit plants, and thus has an excellent cold-tolerance.

Prunus persia showed a good growth rate similar to that of *Diospyros kaki*. In other words, it showed low level of chlorophyll content in January and February 2017 regardless of region, but the level of chlorophyll increased as temperature increased, and electrolyte efflux also decreased significantly in August 2017 (Table 6).

Analyzing the cold-tolerance of the six types of fruit tress implied from these results, *Morus alba*, *Elaeagnus umbellata* var.*coreana*, and *Prunus mume*

Table 3. Changes in chlorophyll and electrolyte values of *Prunus mume* during and after the winter season (by region)

Species	Region	Measurement item	2017.01	2017.02	2017.08	Note
Prunus mume	Yongin	chlorophyll content(mg/g)	5.42±0.07b[z)y)]	10.5±6.54a		death during wintering
		electrolyte values(㎛/sec)	71.82±5.07a	62.92±0.90a		
	Daejeon	chlorophyll content(mg/g)	4.73±0.28b	7.41±2.16a		death during wintering
		electrolyte values(㎛/sec)	47.49±4.70a	68.51±3.14b		
	Jinju	chlorophyll content(mg/g)	5.44±0.15b	9.33±1.67b		death during wintering
		electrolyte values(㎛/sec)	32.56±1.02c	44.99±4.50a		

z) standard error based on sample of treatment

y) Ducan test: mutiple testing, P<0.05

Table 4. Changes in chlorophyll and electrolyte values of *Elaeagnus umbellata* var.coreana during and after the winter season (by region)

Species	Region	Measurement item	2017.01	2017.02	2017.08	Note
Elaeagnus umbellata var.coreana	Yongin	chlorophyll content(mg/g)	22.43±1.28a [z)y)]	26.48±0.93b		death during wintering
		electrolyte values(㎛/sec)	65.83±7.00a	54.22±3.67a		
	Daejeon	chlorophyll content(mg/g)	12.45±0.63c	18.18±1.9a	44.78±1.61a	
		electrolyte values(㎛/sec)	42.36±2.89c	36.18±0.43b	18.00±0.28c	
	Jinju	chlorophyll content(mg/g)	19.63±0.39a	22.99±1.58b	40.59±6.34b	
		electrolyte values(㎛/sec)	53.11±3.20a	55.45±0.16a	9.67±0.77c	

[z)] standard error based on sample of treatment
[y)] Ducan test: mutiple testing, P<0.05

Table 5. Changes in chlorophyll and electrolyte values of Malus domestica 'Alps Otome' during and after the winter season (by region)

Species	Region	Measurement item	2017.01	2017.02	2017.08	Note
Malus domestica 'Alps Otome'	Yongin	chlorophyll content(mg/g)	9.07±0.18a [z)y)]	19.4±1.06a	37.15±4.05b	
		electrolyte values(㎛/sec)	27.54±2.67	27.43±4.00a	5.79±0.36c	
	Daejeon	chlorophyll content(mg/g)	9.70±0.59a	15.96±1.25a	31.77±0.45c	
		electrolyte values(㎛/sec)	26.92±1.30b	16.17±4.96c	6.86±1.49b	
	Jinju	chlorophyll content(mg/g)	8.70±0.35b	21.12±1.66a	32.22±3.71a	
		electrolyte values(㎛/sec)	27.75±5.14a	21.35±3.47c	4.42±0.81c	

[z)] standard error based on sample of treatment
[y)] Ducan test: mutiple testing, P<0.05

died from low temperature during the winter at -7.2℃. In the same condition, *Diospyros kaki*, *Prunus persia*, and *Malus domestica* 'Alps Otome' survived the low temperature damage of winter to restore their physiology and growth. Among them, *Malus domestica* 'Alps Otome' showed the highest level of chlorophyll content during the growth period in August and showed to have the highest cold-tolerance.

Table 6. Changes in chlorophyll and electrolyte values of *Prunus persia* during and after the winter season (by region)

Species	Region	Measurement item	2017.01	2017.02	2017.08	Note
Prunus persia	Yongin	chlorophyll content(mg/g)	8.09±0.18a [z)y)]	19.4±1.06a	37.15±4.05b	
		electrolyte values(㎛/sec)	27.54±2.87	26.43±4.00a	5.79±0.36c	
	Daejeon	chlorophyll content(mg/g)	9.70±0.49a	16.96±1.25a	35.77±0.45c	
		electrolyte values(㎛/sec)	26.92±1.30b	15.17±4.96c	6.86±1.49b	
	Jinju	chlorophyll content(mg/g)	7.90±0.29b	22.12±1.66a	33.22±3.91a	
		electrolyte values(㎛/sec)	78.75±5.34a	21.34±3.47c	4.52±0681c	

[z)] standard error based on sample of treatment
[y)] Ducan test: mutiple testing, P<0.05

Table 7. Physiological resilience of 3 species of fruit trees with cold resistance by region after wintering

Measurement item	Species \ Region	Yongin	Daejeon	Jinju
Chlorophyll content (mg/g)	*Diospyros kaki*	17.41±1.06a[z)y)]	26.38±2.14a	21.00±0.98b
	Prunus persia	47.19±7.14a	31.86±4.78b	36.90±2.97a
	Malus domestica 'Alps Otome'	29.08±2.84a	12.07±1.04a	13.32±0.94b
Electrolyte values (㎛/sec)	*Diospyros kaki*	-13.70±0.67a	-20.48±1.42a	-17.43±0.86b
	Prunus persia	-26.76±1.58b	-30.20±3.94b	-35.75±1.03a
	Malus domestica 'Alps Otome'	-23.55±2.76a	-21.26±1.41a	-22.33±0.78a

[z)] standard error based on sample of treatment
[y)] Ducan test: mutiple testing, P<0.05

3.2. The physiological resilience of 3 types of fruit tress which survived after wintering

After wintering, the growth of fruit tress occur the rapidly from the following year spring to the prime moment of growth and development, so this study figured out the physiological resilience by subtracting the physiological measurement value of January 2017 in which the lowest temperature remains the most during the wintering from the physiological measurement value of the prime moment of the growth and development (August 2017) after wintering.

The Physiological resilience of *Diospyros kaki*, *Prunus persia*, *Malus domestica* 'Alps Otome' that we obtained by subtracting chlorophyll content of Jan. and Feb. 2017 from chlorophyll content of Aug. 2017 (the prime moment of the growth and development in fruit trees), is shown in the Table 7.

It seemed to be different by region. As we measured the physiological resilience with the content of chlorophyll, *Diospyros kaki* contained 16.80 - 25.48 mg/g chlorophyll value, *Prunus persia* contained 32.18 - 48.92 mg/g chlorophyll value, and *Malus domestica* 'Alps Otome' contains 12.17 - 29.92 mg/g chlorophyll value (Fig.1).

If we consider only the chlorophyll content as the physiological resilience of fruit trees, *Prunus persia* has the most physiological resilience in all 3 regions.

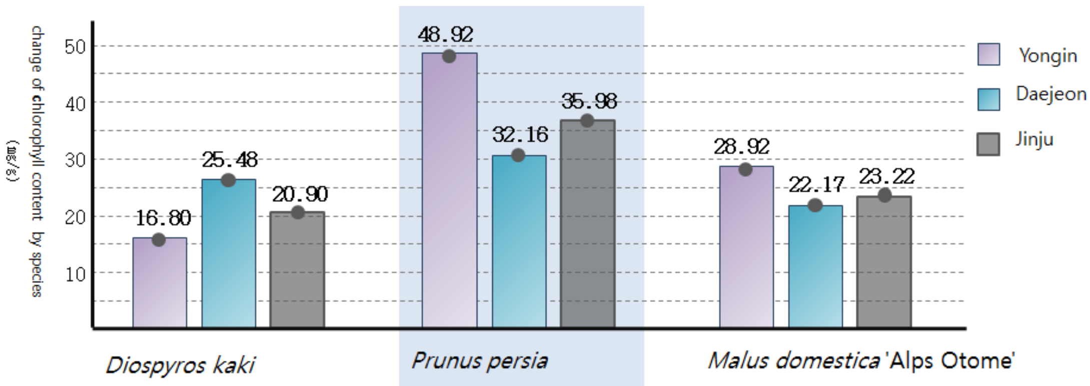

Fig. 1. Comparison of the physiological resilience by regions by looking at the difference of chlorophyll content of 3 species of fruit tress with cold resistance after wintering.

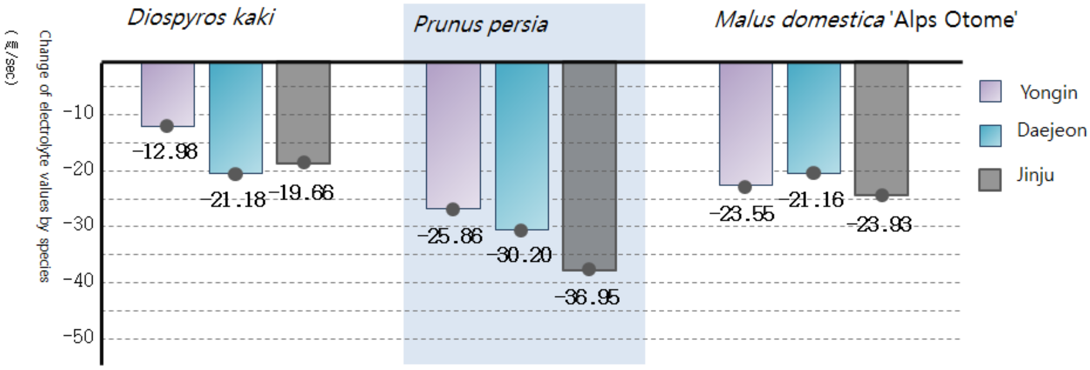

Fig. 2. Comparison of the physiological resilience by regions by looking at the value of electrolyte yield of 3 species of fruit tress with cold resistance after wintering.

If we verify this with the amount of electrolyte yield, *Diospyros kaki* had 12.98 - 21.18 ㎍/g of electrolyte yield, *Prunus persia* had 25.86 - 36.95 ㎍/g of electrolyte yield, and Malus domestica 'Alps Otome' had 21.16 - 23.33 ㎍/g of electrolyte yield.

As we consider only the amount of electrolyte yield of 3 species of fruit tree, *Prunus persia* has the most physiological resilience in all 3 regions.

As we reinterpreted the both data of physiological resilience, *Prunus persia* had more physiological resilience than *Diospyros kaki*, *Malus domestica* 'Alps Otome' in Yong-in, Dae-jun, Jin-ju, and this data shows that *Prunus persia* could be recommended as it had the most cold resistance among those 3 species of fruit tree.

3.3. Growth and physiological resilience of 3 species of fruit tree before and after wintering

In this study, the growth and physiological resilience of 3 species of fruits could be interpreted by subtracting the physiological measurement value of the prime moment of growth and development during the wintering from the value of after the wintering and comparing these values, but if we

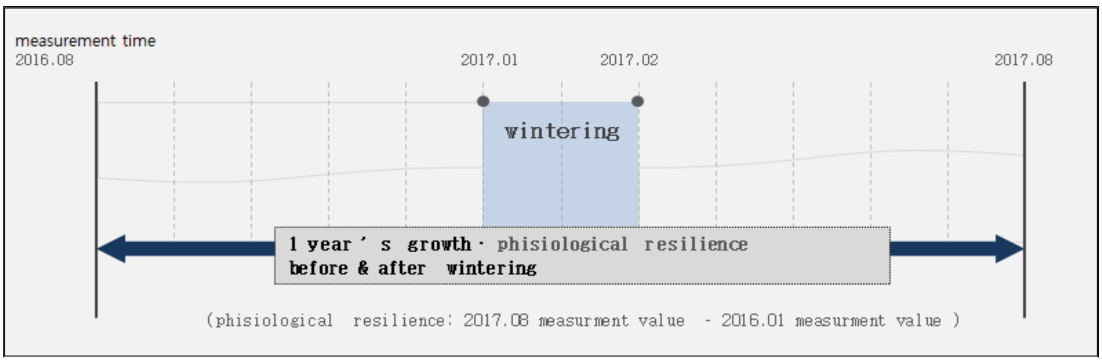

Fig. 3. The concept of growth and physiological resilience 1 year period before and after wintering of 3 species of fruit tree with the cold resistance (Growth resilience: growth measurement value of Aug, 2017 growth measurement value of Aug, 2016 Physiological resilience: physiological measurement value of Aug, 2017 ≒ physiological measurement value of Aug, 2016).

Table 8. Growth resilience by region as considering the difference of growth of *Diospyros kaki* for 1 year before and after the wintering

Region \ Item	Plant height(cm)		Fresh-weight(g)		Dry-weight(g)	
	2010.08	2011.08	2010.08	2011.08	2010.08	2011.08
Yongin	5.52±0.04b z)y)	7.26±1.12a	3.45±0.19a	4.23±1.06b	0.40±0.01b	0.55±0.15a
Daejeon	2.76±0.19b	2.88±0.96a	5.88±0.37a	6.24±0.89ab	0.83±0.13a	0.98±0.37a
Jinju	3.76±0.72b	4.25±1.48a	5.74±1.38a	6.35±0.74ab	0.68±0.07ab	0.40±0.22a

z) standard error based on sample of treatment
y) Ducan test: mutiple testing, P<0.05

discuss the growth and physiological resilience more specifically, the growth and physiological measurement value before 1 year and after 1 year of wintering can be compared. And if we compare the value of 1 year before and the value of the prime moment, and the physiological measurement value reaches to the approximate value of the value of 1 year before, it can be interpreted that the physiological resilience has been accomplished.

And growth measurement value is about plant height, fresh-weight, and dry-weight so if they are bigger that 1 year before, it is interpreted that the growth resilience is high.

Based on this premise, we compared and analyzed the plant height, fresh-weight, and dry-weight items before and after wintering in order to compare the psychologocal resilience of 3 species of fruit tree for 1 year.

In this study, growth resilience involves the meaning of growth, not resilience or restoration, so if the value is the same as 1 year before when the experiement started, it is considered as 100% and if it has grown more, we converted the value of growth in percentage rate.

Diospyros kaki has increased to 5.41 - 13.27% for the plant height, 4.72 - 7.42% for the fresh-weight and 14.52 - 30.21% for the dry-weight in Yong-in, Dae-jun, Jin-ju and the average of plant height was 9.00%, fresh-weight 6.00%, and dry-weight 12.00%. However, it showed to have no statistical significance (Fig. 4).

Therefore we found out that *Diospyros kaki* was

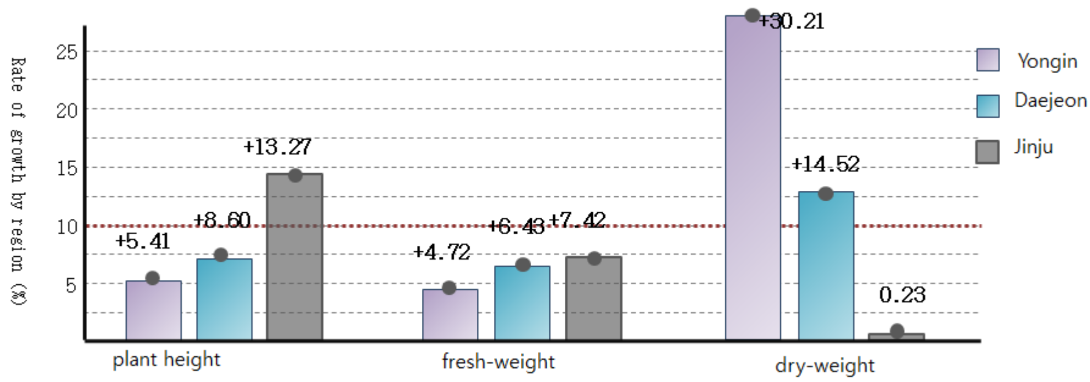

Fig. 4. Growth resilience by region as considering the growth rate of *Diospyros kaki* for 1 year before and after the wintering.

Table 9. Growth resilience by region as considering the difference of growth of *Prunus persia* for 1 year before and after the wintering

Region \ Item	Plant height(cm)		Fresh-weight(g)		Dry-weight(g)	
	2016.08	2017.08	2016.08	2017.08	2016.08	2017.08
Yongin	3.73±1.09a [z)y)]	4.32±0.98ab	2.18±0.34ab	2.52±0.46ab	0.44±0.07a	0.54±0.05ab
Daejeon	2.23±0.94b	4.17±0.82a	1.74±0.05b	1.78±0.47b	0.57±0.24b	0.77±0.39b
Jinju	2.76±0.02ab	3.40±0.29a	2.45±0.74b	2.66±0.59a	0.34±0.05ab	0.57±0.17a

z) standard error based on sample of treatment
y) Ducan test: mutiple testing, P<0.05

planted countrywide because of similar growing regionally after all the coldest winter days.

Prunus persia has increased to 13.12, 77.41, 32.26% for the plant height, 25.72, 14.14, 17.52% for the fresh-weight and 22.23, 50.82, 12.36% for the dry-weight in Yong-in, Dae-jun, Jin-ju and the average of plant height was 14.00%, fresh-weight 19.00%, and dry-weight 28.00% (Fig. 5).

Malus domestica 'Alps Otome' has increased to 13.04, 5.12, 21.23% for the plant height, 17.03, 32.12, 38.31% for the fresh-weight and 18.22, 28.31, 12.17% for the dry-weight in Yongin, Daejun, Jinju and the average of plant height was 13.10%, fresh -weight 29.04%, and dry-weight 19.02% (Fig. 6).

As we consider the physiological resilience of 3 species of fruit tree after wintering by looking at chlorophyll content for 1 year before and after wintering, it has shown that *Diospyros kaki* had the comparison difference of chlorophyll content between 0.79 and 4.51 mg/g for 1 year from each region so it was said to be physiologically restored. *Prunus persia* had between 0.17 to 1.95 mg/g and *Malus domestica* 'Alps Otome' had 1.61 - 2.1 mg/g, so they were said to be physiologically restored. *Prunus persia* had the comparison difference under 1 mg/g and it was the nearest to the physiological measurement value of 1 year before. Thus, *Prunus persia* was the most superior specie based on chlorophyll.

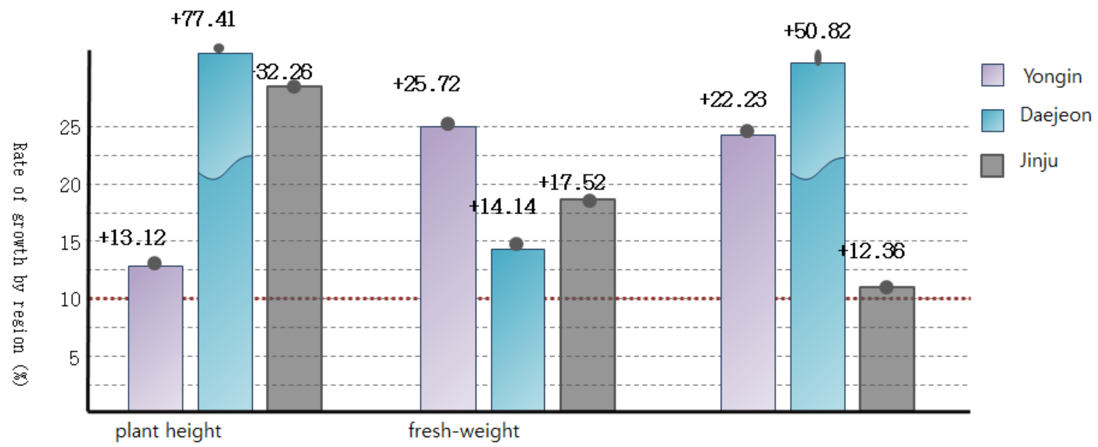

Fig. 5. Growth resilience by region as considering the growth rate of *Prunus persia* for 1 year before and after the wintering.

Table 10. Growth resilience by region as considering the difference of growth of *Malus domestica* 'Alps Otome' for 1 year before and after the wintering

Region \ Item	Plant height(cm)		Fresh-weight(g)		Dry-weight(g)	
	2016.08	2017.08	2016.08	2017.08	2016.08	2017.08
Yongin	12.66±2.48a z)y)	13.16±4.18b	9.82±2.19b	11.72±1.98a	1.43±0.04a	1.67±0.27b
Daejeon	16.38±3.84	18.43±0.94b	11.26±4.25a	14.77±1.84a	1.39±0.47a	1.82±0891a
Jinju	16.27±1.49a	19.76±4.17a	12.43±3.54a	17.61±2.64a	1.27±0.82b	1.37±0.42a

z) standard error based on sample of treatment
y) Ducan test: mutiple testing, P<0.05

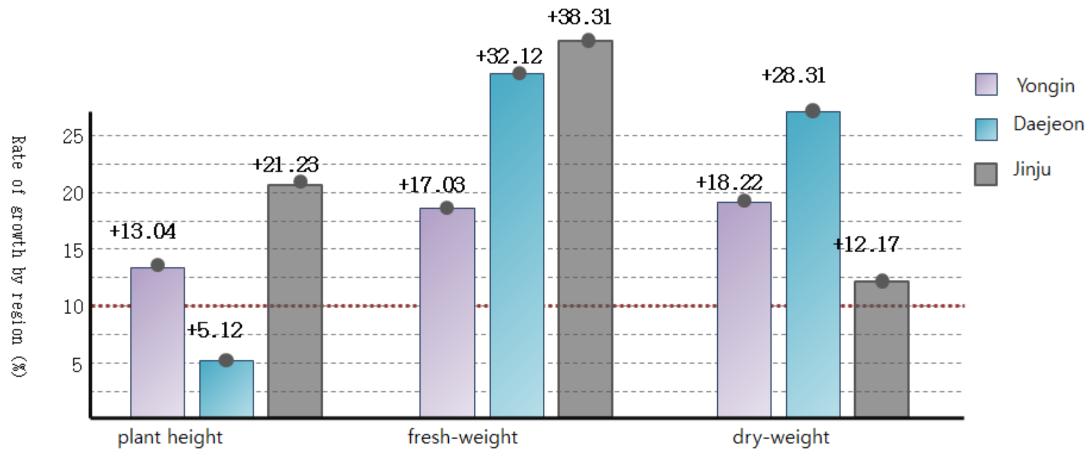

Fig. 6. Growth resilience by region as considering the growth rate of *Malus domestica* 'Alps Otome' for 1 year before and after the wintering.

As we consider the physiological resilience based on the measurement of the amount of electrolyte yield, it has shown that *Diospyros kaki* has the comparison difference of the amount of electrolyte yield between 0.59 and 4.93 ㎛/s for 1 year from each region so it is said to be physiologically restored. *Prunus persia* has between 0.85 to 2.05 ㎛/s and *Malus domestica* 'Alps Otome' has 0.60 - 1.54 ㎛/s,

Table 11. Growth resilience by region as considering the amount value of chlorophyll of 3 species of fruit tree with cold resistance for 1 year before and after wintering

Region \ Species	*Diospyros kaki*		*Prunus persia*		*Malus domestica* 'Alps Otome'	
	2016.08	2017.08	2016.08	2017.08	2016.08	2017.08
Yongin	32.87±2.38a z)y)	31.39±3.24b	46.26±4.52a	45.50±5.14b	37.35±1.52a	35.15±6.34b
Daejeon	40.24±6.559b	35.63±2.88a	36.14±2.11b	38.897±0.99ab	31.26±2.08b	33.77±1.64a
Jinju	32.29±1.54ab	32.10±3.33b	44.27±7334a	44.56±2.10b	34.19±0.74b	34.22±3.17ab

z) standard error based on sample of treatment
y) Ducan test: mutiple testing, P<0.05

Table 12. The physiological resilience by looking at the difference of the electrolyte value of 3 species of fruit tree for 1 year before and after wintering by region

Species / Region	*Diospyros kaki*		*Prunus persia*		*Malus domestica* 'Alps Otome'	
	2016.08	2017.08	2016.08	2017.08	2016.08	2017.08
Yongin	13.45±3.78a z)y)	15.76±6.54ab	8.82±1.48a	10.46±2.17c	4.15±0794c	5.59±1.82b
Daejeon	12.63±2.24b	16.46±4.78a	12.44±1.23ab	11.39±2.09a	6.22±1.26a	6.76±1.07b
Jinju	4422±1.41a	3.83±0.68b	4.39±0.71b	6.54±1.31a	5.12±0.47b	4.52±1.85a

z) standard error based on sample of treatment
y) Ducan test: mutiple testing, P<0.05

so they are said to be physiologically restored. *Diospyros kaki* and *Prunus persia* has the comparison difference under 2.00 ㎛/s and it is the nearest to the physiological measurement value of 1 year before. Thus, *Diospyros kaki* and *Prunus persia* is the most superior species based on the amount of electrolyte yield.

4. Conclusion

The experiment was conducted to verify that 6 species of fruit trees could have even wintering in the suburbs of Seoul (in Yongin city), the central Chungcheong region (in Daejeon city) and the southern Gyeongsang region (in Jinju city) according to the domestic climate condition.

As a result, After interpreting the domestic climate condition, the 6 species of fruit trees in this study were planted in bare grounds in the suburbs of Seoul (Yongin city), the central Chungcheong region (Daejeon city) and the southern Gyeongsang region (Jinju city) in Aug, 2016 and went through wintering and remained until Aug, 2017. Then those surviving trees' growth and physiological measurement data were analyzed and compared, and we did not find any statistical significance related to cold resistance by region. This means that those fruit trees which can be wintering in the southern Gyeongsang region also can do in the suburbs of Seoul and the central Chungcheong region and those surviving fruit trees were not affected by regional climate condition.

This revealed that it was not necessary to limit the region for utilizing fruit trees because the premise that fruit trees would be affected by different domestic climate conditions due to the consideration of cold resistance of fruit trees was not verified.

In Yong-in, 3 species of fruit trees (*Morus alba*, *Elaeagnus umbellata* var. *coreana*, *Prunus mume*) died during the wintering in February, 2017 because of the low temperature but it is not viewed as an usual situation. It was considered to be caused by unexpected abnormal temperature in the capital area during the experiment.

On the other hand, *Diospyros kaki*, *Prunus persia*, *Malus domestica* 'Alps Otome' were concluded to have high cold resistance because they consistently had persuasive date which explained that Aug data had more information than January and February data to explain cold resistance in the aspect of physiological measurement data such as chlorophyll content and electrolyte concentration in the capital, central and southern area. Especially, the increase of the amount of chlorophyll of *Prunus persia* and decrease of the amount of electrolyte content were more remarkable than other 2 species of fruit trees, so *Prunus persia* showed the highest cold resistance among 6 species which were examined.

In addition, it was *Prunus persia* that showed the highest cold resistance from the date of physiological resilience after wintering, growth and physiological resilience for 1 year before and after wintering.

However, the freezing fatality of plant is not simply due to the high or low external temperature, but rather to the physiological conditions of the plant. the Because of factors such as intracellular water content of the plant, intracellular sugar and lipid content and the characteristics of protoplasm (Salisbury and Ross, 1992), it is not appropriate to rush to draw a conclusion from changes in chlorophyll and electrolyte content. Thus, there is a need to test the results of this study with subsequent studies in the future.

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REFERENCES

Anderson, J. A., Kenna, M. P., Taliaferro, C. M., 1988, Cold hardiness of 'Midiron' and 'Tifgreen' bermuda grass, Hort Sci., 23, 748-750.

Cardon, C. A., Duncan, R. R., Lindstrom, O., 1997, Low temperature tolerance assessment in *Paspalum*, Crop. Sci., 37, 1283-1291.

Fanjul, T. J., Rosher, P. H., 1994, Effects of water stress on internal water relations of appleleaves, Plant Physiol., 62, 321-328.

Hietz, P., Briones, O., 2001, Photosynthesis, chlorophyll fluorescence and within-canopy distribution of epiphytic ferns in a Mexican cloud forest, Plant-Biology, 279-287.

Hong, S.-G., Hwang, J.-D., 1978, Cold resistance of Cryptomeria japonica: Difference of collection time for each varieties, J. of Korean Forest Soc., 39, 47-56.

Howell, G. S., Weiser, C. J., 1970, The environmental control of cold acclimation in Apple, Plant Physiol., 45, 390-394.

Iles, J. K., Agnew, N. H., 1995, Seasonal cold -acclimation patterns of *Sedum spectabilex S. telephium* L. 'Autumn Joy' and *Sedum spectabile* Boreau. 'Brilliant', Hort. Sci., 30, 1221-1224.

Kwon, D.-K., Park, Y.-I., Jun, S.-S., Jin, C.-D., 1999, Plant Physiol., Eulyoo Publishing co., 32-57.

Lee, J.-H., Nam, Y.-K., Kwon, O.-M., 2016, The comparison of fruit tree between the capital area and south province depending on the garden farms, Korean Society 2016 Autumn Conference Presentation, Korea, 22- 23.

Salisbury, F. B., Ross, G., 1992, Plant physiology, 4th ed., Wadsworth Inc., Belmont, California.

Willims, J. P., Kahn, M. U., Mitchell, K., Gohnson, G., 1988, The effect of temperature on the level and biosysthesis of unsaturated fetty acids in diacyglycerols of *Brassica napus* leaves, Plant Physiol., 87, 904-910.