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Characteristics of newly bred mulberry variety, 'Saealchan' resistant to sclerotial disease

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Abstract

We bred a mulberry cultivar named 'Saealchan' through local adaptability test, which is under registration as a new cultivar for fruit production. Local adaptability test had been carried out at four local places (Jeonju, Gongju, Jangseong, and Sangju) for five years from 2013. This variety 'Saealchan' belongs to *Morus alba* L. selected from seedlings collected from mother mulberry 'Shimheung'. Saealchan was resistant to popcorn disease and high yielding variety in fruit productivity by 194% compared to control cultivar 'Shimheung (*Morus alba* L.)' for three years. Although fruits of 'Saealchan' was smaller in size and lower in sugar content of mulberry fruits compared to control variety 'Shimheung', it showed strong resistance to sclerotial disease compared to 'Shimheung'.

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Introduction

Mulberry has been cultivated worldwide as a foliage crop for silkworm, and much research has been conducted on mulberry leaves. Because mulberry fruit was considered of no use in silkworm rearing sericulture, mulberry varieties having a minium of fruit are selected for breeding mulberry trees and little research has focused on the fruit.

Recently, mulberry fruit has been proved to have several functional ingredients (Kim and Kim, 2003; Kim *et al.,* 2005a; Kim *et al.,* 1998; Kim *et al.,* 1996; Lee *et al.,* 2003) and increasingly evaluated as desirable food resources in fresh and processed food and drink. With the increasing consumption of the mulberry fruits, it has also greatly increased the cultivated area to 1,309 ha (MAFRA, 2018).

Sclerotial disease of mulberry is caused by a fungus, thus it does no harm to the overall health of the trees for production of leaves. This disease is not considered economically important on cultivating mulberry trees for rearing silkworms. But, sclerotial disease is as serious as 20~30% when cultivating mulberry trees for commercial purposes of fruit production. In addition, its fruits which are known to contain various beneficial substances for human health are commonly consumed in Asia. Annually, the productivity of mulberry fruits is greatly reduced by sclerotial disease, also known as hypertrophy sorosis fruit scleroteniosis, swollen fruit disease, or shrunken fruit disease.

The control methods were developed spraying agricultural chemicals at leaf opening stage, but the nature of eating fresh fruit itself requires sclerotial disease resistant variety. Therefore, we have bred mulberry variety 'Saealchan' that is resistant to sclerotial disease and can produce reliably mulberry fruits. We report briefly the major characteristics and breeding history

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Table 1. Characters of 'Saealchan' compared to control cultivar 'Shimheung' in 2017

Characters	Expression	Grade	Saealchan		Shimheung	
			Grade	Measurement	Grade	Measurement
Shapes of winter buds	Obtuse angled triangular	1	3		1	
	Triangular	2				
	Acute angled triangular	3				
	Spindle shaped	4				
Size of winter buds	Very small	3	3	5.4 mm	3	4.3 mm
	Medium	5				
	Large	7				
Colour of winter buds	Light gray	1	5		3	
	Grayish brown	2				
	Light brown	3				
	Brown	4				
	Reddish brown	5				
	Dark brown	6				
Leaf angle	Obtuse	3	5		5	
	Horizontal	5				
	Acute	7				
Leaf shape	Orbicular	1	2		2	
	Elliptic	2				
	Ovate	3				
	Cordate	4				
	Pentagonal	5				
	Lanceolate	6				
	Pseudomorphic	7				
Depth of leaf lobation	Lobate	3	3		3	
	Medium	5				
	Cleft	7				
Leaf size	Small	3	3		5	
	Medium	5				
	Large	7				
Leaf tip shape	Emarginate	1	3		4	
	Obtuse	2				
	Acute	3				
	Acuminate	4				
	Caudate	5				
Leaf serration	Repand	1	3		3	
	Crenate	2				
	Mucronate	3				
	Serrulate	4				
	Dentate	5				
	Double serrate	6				
	Aristate	7				
Leaf bottom shape	Truncate	1	2		1	
	Retuse	2				
	Cordate	3				
	Closed	4				

Table 1. Continued

Characters	Expression	Grade	Saealchan		Shimheung	
			Grade	Measurement	Grade	Measurement
Leaf color	Yellow	1	7		7	
	Yellowish green	3				
	Light green	5				
	Green	7				
	Dark green	9				
Leaf gross	None	1	3		3	
	Weak	3				
	Medium	5				
	Strong	7				
Leaf wrinkle	None	1	3		3	
	Few	3				
	Medium	5				
	Many	7				
Leaf thickness	Thin	3	5		3	
	Medium	5				
	Thick	7				
Petiole length	None	1	5	40.4 mm	5	43.0 mm
	Short	3				
	Medium	5				
	Long	7				
Phyllotaxis	1/2	1	3		1	
	1/3	2				
	2/5	3				
	3/8	4				
	5/13	5				
No. of shoots	Few	3	7		5	
	Medium	5				
	Many	7				
No. of lateral shoots	None	1	3		3	
	Few	3				
	Medium	5				
	Many	7				
Shoot length	Short	3	5		5	
	Medium	5				
	Long	7				
Shoot size	Thin	3	3		5	
	Medium	5				
	Thick	7				
Shoot color	Light gray	1	2		1	
	Grayish brown	2				
	Greenish brown	3				
	Light brown	4				
	Brown	5				
	Reddish brown	6				
	Dark brown	7				

Table 1. Continued

Characters	Expression	Grade	Saealchan		Shimheung	
			Grade	Measurement	Grade	Measurement
Texture of shoot surface	Fine	1	1		1	
	Coarse	2				
	Scabrous	3				
Tree form	Erect	3	3		3	
	Procumbent	5				
	Dropping	7				
Internodal distance	Short	3	3	39.2 mm	7	65.0 mm
	Medium	5				
	Long	7				
Shape of petiole scar	Circular	1	4		3	
	Elliptic	2				
	Semiicircular	3				
	Triangular	4				
Lenticel size	Small	3	3	1.0 mm	5	2.1 mm
	Medium	5				
	Large	7				
Lenticel density	Low	3	5		3	
	Medium	5				
	High	7				
Sex expression	Staminate	1	5		5	
	Predominantly staminate	2				
	Hermaphrodite	3				
	Predominantly pistillate	4				
	Pistillate	5				
Number of flower clusters	Few	3	7		3	
	Medium	5				
	Many	7				
Fruit weight	Small	3	3	2.8 g	5	3.2 g
	Medium	5				
	Large	7				
Fruit shape	Cylindrical	3	3		3	
	Ellipsoidal	5				
	Globose	7				
Fruit color	Milk white	1	6		6	
	Yellow	2				
	Pink	3				
	Pale purple	4				
	Reddish purple	5				
	Dark purple	6				
	Dark	7				

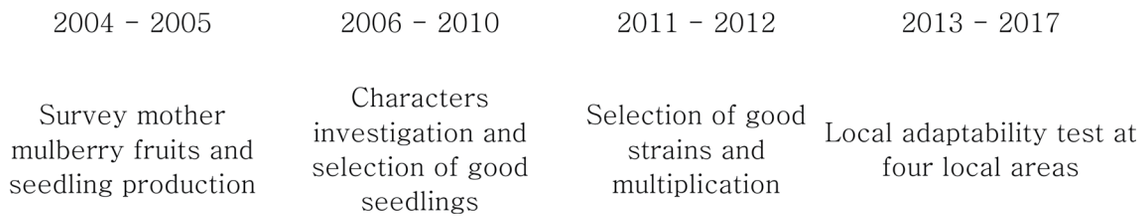

Fig. 1. The pedigree of mulberry cultivar 'Saealchan', selection breeding from seedlings

of the sclerotial disease resistant variety new mulberry variety 'Saealchan'.

Materials and Methods

Characteristics investigation

Morphological and agronomical characteristics were investigated following 'Manual for the characterization and evaluation of mulberry genetic resources' (Machii *et al.,* 1997) in 2017. General characteristics such as leaves, buds, and fruits were carried out shape of winter buds, shape of petiole scar, internodal distance were investigated at dormant stage and leaf shape, depth of leaf lobation, leaf tip shape were investigated at growing stage.

Local adaptability test

Local adaptability test had been carried out for five years from 2013 to 2017 at 4 local places (Jeonju, Gongju, Jangseong, and Sangju) of Korea, following 'Sericultural Experiment Guide' published by RDA using control variety 'Shimheung', which is medium sized and relatively resistant variety to sclerotial disease (Sung *et al.,* 2013). Cultivation of mulberry was conducted following Sericultural Experiment Guide (Kang *et al.,* 2010).

Occurrence rate of sclerotial disease was investigated the number of fruits and diseased fruits at longest fruiting branch and leaf shape was classified by the method proposed by Hotta (1951).

Characteristics of mulberry fruits

Sugar content in a fruit was measured using a refractometer (PR-32α, Atago co. Ltd, Tokyo, Japan) and calculated as the mean of 30 ripe fruits. Acidity in a fruit was measured using a acidity meter (GMK-835, G won hitech co. Ltd, Seoul, Korea) and calculated as the mean of 30 ripe fruits.

Results and Discussion

Breeding history

The 'Saealchan' was selected variety from mulberry seedlings of 'Shimheung' variety relatively resistant to sclerotial disease, which is a serious when mulberry is being cultivated for producing fruits for commercial purposes.

Sowing mulberry seeds of Shimheung at 2004, we produced and transplanted seedlings. Then, we investigated and selected good seedling strain by characteristic investigation for 4 years from 2006 to 2010. Local adaptability test had been carried out at four local places (Jeonju, Gongju, Jangseong, and Sangju) for five years from 2013.

General characteristic

Newly bred mulberry variety 'Saealchan' belong to *Morus alba* L. by the standard of Koidzumi (1917) who classified the genus Morus into 24 species and one subspecies. Figure 2 is the shapes of 'Saealchan' variety with leaves and fruits. Shape of

Fig. 2. Shapes of 'Saealchan' tree with leaves and fruits.

Table 2. Development of winter buds and leaf expending in 2017

Cultivar	Area	Sprouting date	Leaf expending date				
			1st	2nd	3rd	4th	5th
Shimheung	Jeonju	4.24	4.26	4.28	4.30	5.2	5.3
	Gonju	4.16	4.21	4.23	4.25	4.26	4.27
	Jangseong	4.17	4.24	4.26	4.27	4.28	5.1
	Sangju	4.17	4.22	4.24	4.25	4.27	4.28
Saealchan	Jeonju	4.20	4.22	4.24	4.26	4.27	4.30
	Gonju	4.15	4.20	4.22	4.23	4.24	4.25
	Jangseong	4.15	4.22	4.24	4.26	4.28	4.30
	Sangju	4.16	4.21	4.22	4.24	4.25	4.26

Table 3. Characteristics of mulberry fruits and harvesting period('13~'15, Average of 3 years except harvesting period)

Cultivar		Single fruit weight(g)	Sugar content(°Brix)	Acidity(%)	Harvesting period* (Harvest days)
Shimheung	Jeonju	3.6	15.4	0.40	May 23~June 8 (16 days)
	Gonju	3.0	16.4	-	May 23~June 21 (29 days)
	Jangseong	3.3	16.6	-	May 25~June 18 (24 days)
	Sangju	3.2	18.1	-	May 28~June 16 (19 days)
	Average	3.2	16.6	0.40	22.0 days
Saealchan	Jeonju	3.1	15.8	0.40	May 25~June 20 (26 days)
	Gonju	2.7	14.8	-	May 27~June 21 (25 days)
	Jangseong	2.9	17.5	-	May 26~June 26 (31 days)
	Sangju	2.5	14.7	-	May 29~June 22 (24 days)
	Average	2.8	15.7	0.40	26.5 days

petiole scar is acute angled triangular, leaf shape is elliptic, leaf tip shape is acute and leaf bottom shape is retuse. Sex expression is pistillate Phyllotaxis is 2/5, tree form is erect, internodal distance is 39.2 mm which is shorter than control cultivar 'Shimheung' 65.0 mm and number of flower clusters is many, fruit shape of 'Saealchan' is cylindrical, ripe fruit color is dark purple.

Budding and leaf expanding

Budding and leaf expanding is related to late frost damage (Kim 1990), early budding varieties are likely to be late frost damage. Table 2 denotes the development of winter buds and leaf expending in 2015. Saealchan variety showed no significant difference in development of winter buds and leaf expending. In general, we distinguish the four - five days earlier variety early budding variety, the four - five days later variety later budding variety than middle budding variety 'Chungil'. Because 'Shimheung' variety is middle budding like 'Chungil' variety (Sung *et al.,* 2013), 'Saealchan' variety can be described as late frost damage is small variety.

Table 4. Yield of mulberry fruits('15~'17 Average of 4 places)

Cultivar		Yield(kg/10a)				
		Jeonju	Gongju	Jangseong	Sangju	Average(Index)
Shimheung	'15	152	216	153	230	188(100)
	'16	329	38	163	41	143(100)
	'17	231	339	358	150	270(100)
	Average	237	198	225	140	200(100)
Saealchan	'15	261	232	152	432	277(147)
	'16	399	248	261	267	294(205)
	'17	509	539	533	787	592(219)
	Average	390	340	315	495	388(194)

Table 5. Occurrence of sclerotic disease('15~'17, Average of 4 places)

Cultivar	Area	Sclerotic disease(%)			
		'15	'16	'17	Average(Index)
Chungil	Jeonju	11.0	4.2	0.5	5.2
	Gonju	0.0	0.5	0.5	0.3
	Jangseong	5.0	4.8	0.1	3.3
	Sangju	2.7	0.2	0	1.0
	Average	4.7	2.4	0.3	2.5(100)
Saealchan	Jeonju	4.1	2.1	0.2	2.1
	Gonju	0.0	1.0	0.5	0.5
	Jangseong	2.7	2.7	0.2	1.9
	Sangju	1.2	0.6	0	0.6
	Average	2.0	1.9	0.2	1.0(40)

Characteristics of mulberry fruits

Table 3 shows single weight, sugar content, acidity and harvest periods. Mean weight of 'Saealchan' fruits was 2.8 g, which was less than control variety 'Shimheung' 3.2 g. Sugar content and acidity of 'Saealchan' fruits were 15.7°Brix and 0.40% respectively, which were lower than those of control variety 'Shimheung' (16.6°Brix, 0.40%).

Mulberry fruits harvest periods of 'Saealchan' at Jeonju was 26 d (from May 25 to June 20), which was 10 d longer than that of 'Shimheung' variety (16 d). The average harvest period of 'Saealchan' (26.5 d) was 4.5 d longer that of 'Shimheung' (22.0 d). In general, harvest period is a concentrated labor time for mulberry fruit production. Long harvest period of 'Saealchan' variety has an advantage of lowering harvest workforce and reducing the cost of employment.

Fruits productivity

Mulberry begins fruiting from threes after planting. Table 4 shows average productivity of 'Saealchan' variety for 3 years (3rd - 5th year after planting) at four local places. The average yield of new variety, Saealchan, for 3 y from 2015 to 2017 in 4 experimental places (388 kg) was higher 194% than that of control variety 'Shimheung' (200 kg).

The uneven productivity of control variety 'Shimheung' in Gonju and Sanju in 2016 was caused by low temperature damage. On the other hand, the productivity of Saealchan had not affected from low cultivation temperature, Saealchan was considered relatively resistance variety to low temperature cultivation condition.

Resistance to sclerotial disease

Sclerotial disease of mulberry fruit can be controlled by spraying agricultural chemicals at leaf opening stage, but basically cultivating disease resistant variety can produce fruits reliably. Sclerotial disease known as popcorn disease on mulberry fruits is a serious disease for the production of mulberry fruits. Table 5 shows the occurrence of sclerotial disease on mulberry fruits during local adaptability test at four local places. The Saealchan's average sclerotial disease occurrence was 1.0%, down to 60.0% from 2.5 percent of control variety 'Shimheung'. Although the criteria for judging the resistance to sclerotial disease have not been established yet, the resistance to sclerotial disease is determined based on the relative incidence rate of each varieties. Therefore, it is obvious that 'Saealchan' variety has resistance to sclerotial disease.

We had already bred sclerotial disease resistant mulberry 'Shimgang' (Sung *et al.,* 2016), this time we have bred a new mulberry variety 'Saealchan' that is resistant to sclerotial disease, high in yields and low in sugar contents.

Summary

Mulberry fruit has been re-evaluated as desirable food source such as jam, drinks, mulberry wine, etc. and mulberry fruit production became new income sources for farmers in Korea. Sclerotial disease causes to lower the production of mulberry fruit. Therefore, sclerotial disease should be controlled and required for disease resistance variety. New variety 'Saealchan' was bred through local adaptability test in 4 regions for 5 years since 2013.

The major characteristics of mulberry variety 'Saealchan' are as follows;

1. Newly bred mulberry variety 'Saealchan' belongs to *Morus alba* L. by the standard of Koidzumi (1917).

2. Average weight of 'Saealchan' fruits is 2.8 g, which was lighter than 3.2 g of the control variety 'Shimheung'. Sugar content of Saealchan's fruits is 15.7 °Brix, which is lower than the 16.4°Brix of control variety 'Shimheung'.

3. Average productivity of 'Saealchan' variety for 3 years (3rd - 5th year after planting) at four local places was high by 194% compared to control variety 'Shimheung'

4. The Saealchan's average sclerotial disease occurrence (1.0%) was lower than that of control variety 'Shimheung' (2.5%).

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References

Hotta H (1951) Mulberry. pp 16-20. Tokyo.

Kang PD, Sung BG, Ji SD, Kim MJ, Kweon HY, Kang SW (2010) Sericultural experimental guide. Sangroksa, Suwon.

Kim HB, Kim SL (2003) Identification of C3G (cyanidin-3-glucoside) from mulberry fruits and quantification with different varieties. Korean J Seric Sci 45, 90-95.

Kim HB, Kim JB, Kim SL (2005a) Varietal analysis and quantification of resveratrol in mulberry rruits. Korean J Seric Sci 47, 51-55.

Kim HB, Sung GB, Kang SW (2005b) Evaluation of fruit characteristics according to mulberry breeding lines for fruit production. Korean J Crop Sci 50, 224-227.

Kim MH (1990) Mulberry. pp. 342 - 343. Hyangmunsa, Seoul.

Kim SY, Park KJ, Lee WC (1998) Antiinflammatory and antioxidative effects of Morus spp. fruit extract. Korean J Medicinal Crop Sci 6, 204-209.

Kim TW, Kwon YB, Lee JH, Yang IS, Youm JK, Lee HS, *et al.* (1996) A study on the antidiabetic effect of mulberry. Korean J Seric Sci 38, 100-107.

Koidzumi G (1917) Taxonomical discussion on Morus plants, Bull Imp Sericult Exp Stat 3, 1-52.

Lee WC, Kim AJ, Kim SY (2003) The study on the functional materials and effects of mulberry leaf. Food Sci Ind 36(3), 2-14.

Machii H, Akio K, and Yamanouchi H and Katakiri K (1997) Manual for the characterization and evaluation of genetic mulberry genetic resources. Misc Publ Natl Inst Seric Entomol Sci 22, 105-124

MAFRA (2018) 2017 government statistics on functional sericulture.

Sung GB, Kim HB, Kang PD, Kim KY, Ji SD (2013) Characteristics of mulberry cultivar Shimheung (Morus alba L.) for mulberry fruit production. J Seric Entomol Sci 51(2), 1-7.

Sung GB, Seo SD, Kim YS, Ju WT, Kim HB, Kim KY(2016) Breeding of mulberry variety "Shimgang" showing resistance to popcorn disease. Int J Indust Entomol 33(2), 41-47.