

## Breeding of a New Silkworm Variety, Chugangjam, with a Sex-Limited Larval Marking and High Silk Yielding for Summer-Autumn Rearing Season

Pil Don Kang\*, Bong Hee Sohn, Sang Uk Lee, Soon Ok Woo and Sung Jin Hong

Department of Sericulture and Entomology, National Institute of Agricultural Science and Technology, RDA, Suwon 441-100, Korea.

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A new silkworm variety, Chugangjam, with a sex-limited larval marking and high silk yielding for summer-autumn rearing season is F<sub>1</sub> hybrid between Jam 147, a Japanese race bred from P8503/8453, and Jam 148, a Chinese race from M8306/Jam 130. Jam 147, Japanese parent of the Chugangjam showed a high GCA (general combining ability) in pupation percentage and Jam 148, Chinese parent, showed a high GCA in pupation percentage and single cocoon weight. In the local adaptability test performed at 8 local areas in autumn of 2001, Chugangjam was 5% higher in cocoon yield and 8% in raw silk productivity in the 10,000 of the 3rd molted larvae, respectively, than the check variety Daesungjam.

**Key words:** Silkworm, Breeding, Sex-limited larval marking, High silk yielding, Chugangjam, Combining ability

### Introduction

Silkworms are well-known industrial insects, which produce natural fiber silk. Because of economic importance for silk yarn, an effort to breed new silkworm variety has been made for thousand years. High cocoon yielding due to high resistance, high silk reeling ability and productivity, better silk quality in neatness and lousiness is essential for new silkworm variety to increase silk productivity. Today, several hundred varieties have been bred accordingly various interests and purposes (Kang *et al.*, 2001,

2002; Lee and Kim, 2000; Sohn *et al.*, 1987).

The most important thing in general sericulture is to breed a new silkworm variety with high silk yielding. Pupation rate, single cocoon weight, cocoon shell weight and cocoon shell percentage are the main factors affecting the high yielding of cocoon (Kang *et al.*, 2001, 2002). And mulberry leaves, rearing temperature and humidity are highly related to the weight of pupa. The breeding activities aimed to create new variety in high unit productivity has been needed for autumn rearing season because of poor mulberry leaf condition and rearing condition in terms of temperature and humidity in the autumn season. The silkworm varieties for autumn have been already bred. These include several varieties of silkworm, such as hybrid between Jam 119 and Jam 120 (Lee *et al.*, 1980), Daesungjam (Sohn *et al.*, 1987), Bunongjam (Hong *et al.*, 1992), and non-cocooning variety Hachojam (Kang *et al.*, 2002). Up to now Daesungjam is widely used as a recommended variety for autumn season.

Here, we report the new silkworm variety with a sex-limited larval marking and high silk yielding, Chugangjam, which was nominated in 2002 as a new recommended variety for autumn rearing season. The variety was bred through generation combining ability test and local adaptability test in Korea. In the present report, the major breeding schemes and important characteristics of Chugangjam are described.

### Materials and Methods

A silkworm variety, Chugangjam, in this study is F<sub>1</sub> hybrid between Japanese race Jam 147 and Chinese race Jam 148. For the target to breed healthy and heavy pure lines, Japanese pure line Jam 147 (breeding line JS143)

\*To whom correspondence should be addressed.

Department of Sericulture and Entomology, National Institute of Agricultural Science and Technology, RDA, Suwon 441-100, Korea. Tel: 82-31-290-8486; E-mail: kangpd@rda.go.kr

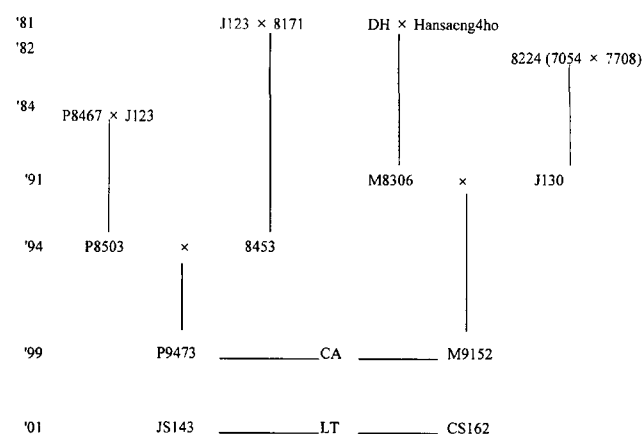
was crossed between stock lines of P8503 and 8453 in 1994 and Chinese race pure line Jam 148 (breeding line CS162) was also crossed between stock lines of M8306 and Jam 130 in 1991.

Targeted characters were selected through two or three times rearing a year with succeeding generation by mass selection in mixed batch rearing system from filial one to filial three and by individual selection in batch rearing system from filial four ( $F_4$ ) to filial eight ( $F_8$ ) mainly based on cocoon quality (Kang *et al.*, 2001). Chugangjam was selected as the variety with an excellent combination in the combining ability test in autumn rearing season of 1999 and spring rearing season of 2000, and it was passed the test of pure line characteristics and adaptability test for autumn rearing season, performed at the Department of Sericulture and Entomology, National Institute of Agricultural Science and Technology (NIAST), and seven Provincial Institute of Agricultural Science and Technology (PIAST), Korea, in autumn rearing season of 2000 and spring rearing season of 2001. It was nominated as a new recommended variety suitable for autumn rearing season with the name of Chugangjam by Nomination Council of Silkworm Recommended Variety (NCSR) after the superiority as an autumn variety was recognized through the local adaptability test performed at seven sericultural organizations of PIAST.

## Results and Discussion

### Combining ability test

For the breeding of a new silkworm variety suitable for autumn rearing season, Japanese race Jam 147 and Chinese race Jam 148 were crossed. Japanese race pure line Jam 147 (breeding line JS143) was selected by crossing between stock lines of P8503 and 8453, and Chinese race pure line Jam 148 (breeding line CS162) was also bred by crossing between stock lines of M8306 and Jam 130. The  $F_1$  hybrid between Jam 147 and Jam 148 was selected as



**Fig. 1.** The Pedigree of “Chugangjam”, the  $F_1$  hybrid between Jam147 Jam148.

CA: Combining ability test, LT: Local adaptability test.

Chugangjam (Fig. 1). The economic characteristics of Jam 147 and Jam 148 were described in Table 1.

The results of three by three ( $3 \times 3$ ) top cross between Japanese and Chinese races with control variety Baegokjam (Lee *et al.*, 1984) performed in autumn rearing season of 1999 and spring rearing season of 2000 are shown in Table 2. The major commercial characteristics of Chugangjam were compared with the reference variety Baegokjam. Chugangjam recorded high pupation rate of 96.4% and showed a heavier single cocoon weight (2.67 g) than Baegokjam (2.56 g). Furthermore, Chugangjam showed higher raw silk productivity than the reference variety Baegokjam. Jam 147, Japanese race parent of Chugangjam, showed high general combining ability (GCA) in pupation percentage and cocoon shell weight out of examined important commercial characters, and Chinese parent of Chugangjam Jam 148 recorded high GCA in cocoon filament length.

### Local adaptability test

**Rearing:** Cooperative experiment for the productivity test

**Table 1.** The economic characteristics of the parental lines and their  $F_1$  performances of Jam147 and Jam148

Line	Rearing season	Larval period	Pupation percentage	Cocoon yields from 10,000 3rd molted larvae	No. of cocoon per liter	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage
		days. hrs	%	kg	ea	g	cg	%
P8503	'94spring	25.23	89.2	16.4	77	1.98	50.0	25.2
8453	'94spring	25.21	94.9	18.8	74	2.11	49.3	23.4
Jam147	'94summer	23.02	91.4	16.3	81	2.03	48.4	23.9
M8306	'91spring	24.04	86.0	16.0	63	2.08	50.2	24.1
Jam130	'91spring	25.03	93.5	20.0	55	2.22	58.1	25.0
Jam148	'91summer	23.01	88.5	18.9	60	2.14	51.8	24.2

**Table 2.** The major commercial characteristics of Chugangjam and the general combining abilities (GCA) of its parental lines in spring 2000

Variety	Pupation percentage	Cocoon yield from 10,000 3rd molted larvae	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage	Cocoon filament length	Raw silk percentage	Raw silk yield
	%	kg	g	cg	%	m	%	kg
Baegokjam	89.7	21.9	2.56	61.6	24.1	1,418	21.48	4.70
Chugangjam	96.4	24.9	2.67	63.4	23.8	1,456	20.98	5.22
GCA of Jam147	1.9	1.0	0.03	1.3	0.25	-47.0	-7.3	0.23
GCA of Jam148	0.2	-0.1	-0.03	-1.1	-0.11	37.6	0.5	0.07

The general combining abilities (GCA) of Jam147 and Jam148 were calculated out of 9 top-cross sets between 3 Japanese and 3 Chinese lines performed in spring 2000.

**Table 3.** Rearing results of Chugangjam through the local adaptability test performed at 8 places in spring 2001

Variety	Useful hatchability	Larval period	Pupation percentage	Best cocoon rate	Double cocoon rate
	%	days. hrs	%	%	%
Daesungjam	94	24.21	93.0	93.2	1.3
Chugangjam	94	24.07	93.3	94.8	0.8

Variety	Cocoon yield per 10,000 3rd molted larvae	No. of cocoons per liter	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage
	kg	ea	g	cg	%
Daesungjam	17.2	71	1.93	46.4	24.0
Chugangjam	18.2	64	1.95	46.9	24.1

and local adaptability of Chugangjam was performed at the Department of Sericulture and Entomology, NIAST, and seven PIAST. The results of Chugangjam through the local adaptability test are shown in Table 3. The useful hatchability of Chugangjam (94%) was over 90% of recommending criteria for a new variety. This value is same level to check variety Daesungjam. The larval duration of Chugangjam was 14 hrs shorter than that of check variety. Pupation rate of Chugangjam was also passed the recommending criteria of 92% of recent three varieties (based on autumn record of 2001) as 93.3%, which recorded 0.3% higher than check variety. The cocoon yield of Chugangjam was 1.0 kg heavier than check variety, which showed 18.2 kg per 10,000 of 3rd molted larvae. The result shows the increase of cocoon yield due to the weight and size of single cocoon of Chugangjam compared with check variety, indicating that Chugangjam can be used as high silk yielding variety for autumn rearing season.

**Reeling:** Cocoon and raw silk characteristics of Chugangjam compared with check variety Daesungjam are shown in Table 4. Filament length of Chugangjam with 1,382 m was 81 m longer than the check variety Daesungjam with

1,301 m, but filament weight of Chugangjam with 41.3 cg was 1.0 cg heavier than check variety with 40.3 cg. Cocoon reelability and non-broken filament length in the Chugangjam were 73% and 998 m, respectively. The neatness, degumming rate and lousiness of raw silk grade of Chugangjam were 88 points, 25.6% and 79 points, respectively.

**Adaptability test for the artificial diet at young larval stages:** The results of the adaptability test for artificial diet of young silkworm of Chugangjam were illustrated in Table 5. Chugangjam was not recommendable for artificial diet with low adaptability compared with check variety Baegokjam, which was widely propagated for artificial diet.

**Main characteristics of parental lines:** The major characteristics of Jam 147 and Jam 148, which are parental lines of Chugangjam were examined with Jam 125 and Jam 126, which are parents of Daesungjam, as controls are illustrated in Table 6. Japanese race Jam 147 showed plain on larval marking and peanut shape cocoon, and pupation rate and cocoon yields by 10,000 of the 3rd molted larvae with 95.5% and 16.1 kg were improved

**Table 4.** Cocoon reeling results of Chugangjam through the local adaptability test performed at 8 places in spring 2001

Variety	Filament length	Filament weight	Filament size	Reelability	Non-broken filament length	Non-broken filament weight
	m	cg	d	%	m	cg
Daesungjam	1,301	40.3	2.80	74	958	30.0
Chugangjam	1,382	41.3	2.70	73	998	30.2

Variety	Raw silk percent	Raw silk yield	Neatness	Degumming rate	Lousiness
	%		point	%	point
Daesungjam	19.47	3.35	94	24.8	82
Chugangjam	19.97	3.64	88	25.6	79

Raw silk yield was calculated from multiplication between cocoon yield per 10,000 3rd molted larvae and raw silk percent.

**Table 5.** Adaptability test of the artificial diet of silkworm in spring, 2002

Variety	Bristling rate	Larval period from 1st to 3rd	Molting rate			Adaptability
			2nd	3rd	4th	
	%	days. hrs	%	%	%	
Baegokjam	96	12.08	96	95	96	Good
Chugangjam	80	12.08	70	88	93	-

**Table 6.** The major commercial characteristics of the parents of Chugangjam

Variety	Useful hatchability	Larval period	Pupation rate	Cocoon yield per 10,000 3rd molted larvae	Single cocoon weight	Cocoon shell weight	Cocoon shell percentage
	%	days. hrs	%		g	cg	%
Japanese races							
Jam125	92	24.22	94.7	15.6	1.77	43.5	24.6
Jam147	88	23.22	95.5	16.1	1.80	39.7	22.0
Chinese races							
Jam126	98	23.23	95.0	16.1	1.77	40.6	23.0
Jam148	86	24.04	90.5	15.3	1.84	42.6	23.1

Variety	Percentage of moth emergence	Duration from incubation to moth emergence	No. of eggs per batch	Percentage of moth laid normal eggs	Laval marking	Cocoon shape
		days	ea			
Japanese races						
Jam125	99	57	463	78	mark	peanut
Jam147	100	56	527	100	plain	
Chinese races						
Jam126	100	55	559	100	♂ plain	elliptical
Jam148	99	56	494	94	♀ mark	

0.8% and 0.5 kg than check variety Jam 125, and fecundity with 527 each per moth also increased than that of 463 each of Jam 125.

Chinese race Jam 148 showed a sex-bases larval marking: body marking on female and plain on male with elliptical cocoon shape. The pupation rate and cocoon yields

by 10,000 of the 3rd molted larvae with 90.5% and 15.3 kg were relatively decreased to those of check variety Jam 126 and fecundity with 494 each per moth was also decreased than that of 559 each of Jam 126.

In conclusion, a new silkworm variety, Chugangjam, showed higher pupation rate and heavier cocoon yields

than check variety. This new variety Chugangjam can be used as a variety for autumn rearing season.

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